Proceedings Symposium '88

on Veterinary Epidemiology, Zoonoses, and Economics

September 26-27, 1988
Bethesda, Maryland

Sponsored by American College of Veterinary Preventive Medicine and APHIS

Compiled by A. S. Ahl, DVM, PhD

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American College of Veterinary Preventive Medicine
and
USDA/Animal and Plant Health Inspection Service
present

Symposium '88

on

Veterinary Epidemiology, Zoonoses, and Economics

September 26-27, 1988 -- 8-5 p.m.

Ramada Inn
8400 Wisconsin Avenue
Bethesda, Maryland

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Registration fee is $100.00, payable at the door. APHIS personnel should use SF-182 to pay. Vendor is ACVPM, Dr. Ed Menning, 1023 15th Street, NW, Suite #300, Washington, D.C. 20005.

PROGRAM FOR THE ACVPM/APHIS SYMPOSIUM

REGISTRATION: In the lobby of the Ramada Inn, 8400 Wisconsin Avenue, Bethesda,, Maryland, located at the corner of Wisconsin and Battery Lane

The nearest Metro is Medical Center Station on the Red Line, about 1/4 mile north of the Ramada Inn. You may call 654-1000 for the Ramada Inn Van Metro Station pick-up.

There are no parking fees for conference guests using the Ramada Inn parking ramp.

Registration fees are payable by cash, check, money order, or SF-182 for federal employees. Students and retirees are our guests.

PROGRAM NOTE: Monday´s speakers are guests of ACVPM; Tuesday´s speakers are all APHIS veterinarians except as marked in parentheses.

Monday, September 26, 1988

8:30 - 8:40	Welcome and Introduction
8:40 - 10:10	"How much money does this disease cost anyway?--Good question!" E. H. McCauley, DVM, MS, Consultant and Adjunct Faculty, University of Minnesota, St. Paul, MN
10:10 - 10:40	Break
10:40 - 12:10	"Epidemiologic Modeling as an Aid to Decision Making," T. E. Carpenter, PhD, Associate Professor, University of California, Davis, CA
12:10 - 1:45	Lunch
1:45 - 2:15	"Toxoplasmosis," J. P. Dubey, MVSC, PhD, USDA/ARS, Beltsville, MD
2:15 - 2:45	"Streptococcosis," E. D. Erickson, DVM, PhD, Professor, University of Nebraska, Lincoln, NE
2:45 - 3:15	Break
3:15 - 3:45	"Cysticercosis," J. R. Weedon, DVM, MPH, Texas Department of Health, Austin, TX
3:45 - 4:15	"Cryptosporidiosis," H. W. Moon, DVM, PhD, USDA/ARS, Ames, IA

TUESDAY MORNING, SEPTEMBER 27, 1988

Session A - Ballroom (COMPUTER APPLICATIONS)	Time	Session B - Meeting Room
Introduction and Welcome	8:00	Introduction and Welcome
	8:10	
- Design of a database for the geographic distribution of domestic species, C. Campbell, DVM, MPVM, Englewood, CO; J. Belfrage, DVM, MPVM, San Bernardino, CA	8:20	- An investigation of akabane, G. Svetlik, DVM, Georgetown, TX (VECTORS AND PARASITES)
	8:30	
	8:40	
	8:50	
	9:00	- Patterns of infestation with the tropical bont tick within St. Croix, U.S. VI and Puerto Rico, B. H. Bokma, DVM, MPVM, San Juan, PR
	9:10	
- Epidemiological applications of a database management system for the bovine TB eradication program, R. Meyer, DVM, Ft. Collins, CO	9:20	- Tropical bont tick spread in the Caribbean--how probable is it?, F. J. Alderink, DVM, MS, Hyattsville, MD
	9:30	
	9:40	- Managerial factors associated with disease seropositivity: a study of trichinosis in NC, R. Pacer, DVM, Tampa, FL (with P. Cowen, DVM, PhD; P. N. Van Peteghem, PhD; J. Fetrow, DVM, MBA, NC State University
	9:50	
- Automated traceback system for cattle, M. Pavlick, DVM, Renfro Valley, KY	10:00	- Frequency of Alternative Host Parasitism of <u>Boophilus microplus</u> in an eradication program, J. Duncan, DVM, San Juan, PR
	10:10	
- A model for monitoring turkey salmonellosis, M. McBride, DVM, Sacramento, CA	10:20	- E. coli O 157; H-7: on the trail of a reservoir. L. Shipman, DVM, Harrisburg, PA
	10:30	
	10:40	- Preventive veterinary medical aspects of international germ plasm exchange, J. Acree, DVM, MPVM, Hyattsville, MD (PREV. MED.)
	10:50	
- A profile of epidemiology literature, E. I. Pilchard, DVM, PhD, Hyattsville, MD	11:00	- The occurrence of drug residues in Michigan dairy cattle, meat, and milk, A. S. Ahl, DVM, PhD, Hyattsville, MD (with J. B. Kaneene, DVM, PhD, MPH; J. Marteniuk, DVM, MS; P. Bartlett, DVM, MI State University)
	11:10	
	11:20	
	11:30	

. . . . LUNCH FROM 11:30 a.m. until 1:00 p.m. ....

TUESDAY AFTERNOON, SEPTEMBER 27, 1988

Topic	Session A - Ballroom	Time	Session B - Meeting Room	Topic
NAHMS	- An historical perspective on NAHMS, L. King, DVM, MPH, Washington, DC	1:00	- Infections laryngotracheitis epornitic, D. C. Johnson, DVM, Conyers, GA	VIRAL DISEASES
	- NAHMS investigations in the Southeast Region, C. Erbel, DVM, Nashville, TN (with J. New, DVM, MPH, Knoxville, TN)	1:10		
		1:20	- Infectious laryngotracheitis in northern GA 1988: a progress report, R. Pacer, DVM, Tampa, FL	
	- List frames for sampling NAHMS beef herds in CA, C. Danaye Elmi, DVM, Sacramento, CA	1:30		
		1:40	- Epidemiology of vesicular stomatitis in Mexico, field studies, J. Mason, DVM, MPH, Mexico City, MX	
		1:50		
	- Mortality and Morbidity, NAHMS Round 2, dairy cattle in CA, C. Danaye Elmi, DVM, Sacramento, CA	2:00		
		2:10		
	- NAHMS Swine survey: experience from the pilot states, J. Farrar, DVM, MPH, Ft. Collins, CO	2:20	- Scrapie as we know it: why there are inherent epidemiological flaws, L. Detwiler, DVM, Trenton, NJ	
		2:30		
BRUCELLOSIS	- Brucellosis epidemiology and the ND Lone Oak Cattle Co., R. Sanders, DVM, MS, Ft. Worth, TX	2:40		
		2:50		
	- The significance of biovar in the epidemiology of bovine brucellosis in Puerto Rico: outbreak and tracing activities, B. H. Bokma, DVM, MPVM, E. Rossy, DVM, San Juan, PR	3:00	- The importance of singleton reactors to pseudorabies virus: a retrospectie analysis, J. F. Annelli, DVM, MS, St. Paul, MN, (with R. B. Morrison, DVM, PhD, and D. G. Thawley, BVSc, PhD, University of Minnesota)	
		3:10		
		3:20		
		3:30		
	- Use of adult vaccination in brucellosis eradication in CA, (R. Breitmeyer, DVM, State of CA VMO, Sacramento, CA)	3:40	- Pork producers and the cost of pseudorabies, F. J. Alderink, DVM, MS, Hyattsville, MD	
		3:50		
		4:00		
		4:10		
	- Summary of post brucellosis adult vaccination testing in FL, E. Arza, DVM, Jacksonville, FL	4:20		
		4:30		
	- Field evaluation in FL of the PCFIA Test in brucellosis adult vaccinated herds, D. Warner, DVM, Sebring, FL	4:40		
		4:50		

AMERICAN COLLEGE OF VETERINARY PREVENTIVE MEDICINE
SYMPOSIUM 1988, BETHESDA, MARYLAND

"HOW MUCH MONEY DOES THIS DISEASE COST ANYWAY? - GOOD QUESTION!"

Dear Friends:

These attachments are from economic evaluations of animal disease impact on production and consequences of public investments in control programs. Rather than to show the findings themselves, these sections were selected to show "process" and approaches to the following issues or questions which are key elements that have to be understood and defended:

1. The original question itself and the reason for the study. Clear definition of the objectives and intended use of the information must be established at the onset.

2. The establishment of a temporal framework and reasonable times of occurrences of benefits and costs. The "time value of money".

3. The estimation of <u>annual</u> (calendar year), product-losses avoided. This is a composite of:

    a. Acceptability of diagnostic quality.

    b. Probability of exposure - roughly from prevalence surveys.

    c. Estimation of annual, new, clinical-case incidence either retrospectively or prospectively.

    d. Conversion of that incidence to production losses. Information on this question is usually the most difficult to find. What happens to these clinical cases in terms of uncompensated growth delay, reproduction problems, milk and wool losses, and so forth? Realistic standards of production under the nutritional environment and other animal science data must be taken into account in making these estimations.

    e. Estimating the efficacy (e.g., vaccine quality and realistic judgements of abilities to carry out effective and continuous programs) of control techniques towards reducing these losses and thereby yielding annual increases in product supply with the same inputs of production. Associated with this topic is the need to consider the wisdom of intervening in the opportunities for animals to naturally acquire immunity against the disease in question or other diseases - particularly important for diseases transmitted by insects.

4. The methods of placing financial values on the increased supply (product-losses avoided) and approaches to estimating the economic consequences.

I marked asterisks in several places to highlight issues or discussions that are important considerations (in my opinion) for designing, doing, and/or using studies on the economic consequences of animal diseases and control.

Note that in the schistosomiosis and hog cholera studies the findings are presented as ranges of high and low possibilities to reflect the quality of data and allow for use of various assumptions. It is argued that this range captures the most likely and defensible relationships of benefit and costs. Some estimates actually come out negative - a credible reality!

The whole idea is to provide decision makers with a useful tool. One that takes into account the major technical and economic aspects of the disease impact and control consequences and that is defensible before the several disciplines involved - <u>and</u> is consistent with practicalities of livestock production. The realities of the producers' world and the degree of their willingness to cooperate are issues that should be part of early considerations about hypothetical programs. If not, the study is only a paper exercise.

Respectfully,

E. Hunt McCauley, DVM, MS
College of Veterinary Medicine
University of Minnesota

Note to Attendees:

The documents demonstrating the various points, which were attached to this introductory note for the meeting, are not included since, with exception of the "Hog Cholera in Honduras" paper, they are published and cited below. Persons interested in the hog cholera work can receive it by sending $5.00 to me (Box 709, Gibson Route, Big Timber, MT 59011).

McCauley, E.H., Aulaqi, N.A., Sundquist, W.B., New, J.C. and Miller, W.M. "A Study of the Potential Economic Impact of Foot-and-Mouth Disease in the United States." USDA Technical Bulletin 1597, U.S. Government Printing Office, hardbound, 241 pages, 1979.

McCauley, E.H., Majid, A.A., Tayeb, A. and Bushara, H.O. "Clinical Characteristics of Naturally Occurring Schistosomiasis ("gorag") in Sudanese Cattle." Trop. An. Health and Prod., 15 (1983), 129-136.

McCauley, E.H., Tayeb, A., and Majid, A.A. "Owner Survey of Schistosomiasis Mortality in Sudanese Cattle." Trop. An. Health and Prod. 15 (1983), 227-233.

McCauley, E.H., Majid, A.A., and Tayeb, A. "Economic Evaluation of the Production Impact of Bovine Schistosomiasis and Vaccination in the Sudan." Prev. Vet. Med., 2 (1984) 735-754.

Streptococcal Zoonoses

by

E. Denis Erickson

University of Nebraska - Lincoln

September 26, 1988

Streptococcal infections are not the first which come to mind when making a list of zoonotic diseases, nevertheless, there are several examples of diseases in man and animals caused by the same species of streptococci and there is at least one example of animal to human spread of life threatening illness. In this discussion, we will briefly review the historical aspects of streptococcal disease, enumerate those pathogenic streptococci of interest and lastly focus on a potentially serious zoonosis.

While streptococci were observed in suppurative infections in the early days of clinical microbiology, much confusion reigned, regarding their classification and relationship to specific disease syndromes, until the early 1930's. At this time, Rebecca Lancefield[1] and colleagues established a system of classification based on the serological precipitations of extracted cell wall components. She designated each distinct group of isolates by a letter and noted patterns related to clinical syndromes from which these isolates were made. This allowed for accurate epidemiological studies of steptococcal disease, rampant in the preantibiotic period. It is interesting to note that these infections are still a concern in both veterinary and human medicine.

Most isolates obtained from septic sore throat, impetigo and other streptococcal infections of humans fell within serogroup A

(Streptococcus pyogenes). While there are scattered reports of Group A streptococcal isolations from dogs, this is a rare finding in domestic animals.[2] In spite of this, veterinarians and diagnostic laboratories are frequently asked to examine and culture dog's throats because of persistent pharyngitis in a family. Serological grouping and serotyping would be necessary to support a supposition that Group A beta-hemolytic streptococci were transferred between dogs and human patients.

Group B contains the single species Streptococcus agalactiae. This organism has been isolated from a variety animals but is best known as a cause of bovine mastitis.[3] In the past fifteen years, Group B streptococci have been recognized as a major cause of human neonatal sepsis and meningitis.[4] The organism is believed to reside in the gastrointestinal tract and vaginal canal of carrier women and in members of the perinatal nursing staff which may serve as sources of infection. Colleagues in human medicine have been reluctant to use the species name S. agalactiae for these isolates and, in fact, there are minor differences in some biochemical reactions of isolates from the two sources. The latest edition of Bergey's manual, however, treats all isolates as one species.[5] It is not clear that a direct animal-to-human spread occurs routinely, but rather there may be separate reservoirs in these two hosts with occasional cross-infection.

Streptococci belonging to Group C are found in a variety of hosts and fall within one of several species.[3] None of these is of major zoonotic concern. Streptococcus zooepidemicus has been recovered from cases of pharyngitis in human beings but this is

[illegible] ten days. His is a [illegible] this, vets, [illegible] and [illegible] key to examine and culture [illegible] mastitis in [illegible]. Serological typing would be necessary to support a suggestion [illegible]-hemolytic streptococci were transferred between [illegible] patients.

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[illegible] cocci belonging to Group C are found in a variety of [illegible] fall within one of several species.[illegible] None of [illegible] of zoonotic concern. Streptococcus zooepidemicus has [illegible] in human beings but this is

rare. *Streptococcus equisimilis* has also been recovered from a variety of syndromes in both animals and human beings, but a clear case of zoonosis is not apparent. *Streptococcus dysgalactiae*, a cause of bovine mastitis and *Streptococcus equi*, the cause of equine strangles are virtually host specific.

Streptococci belonging to Group D, including enterococci and nonenterococci, are ubiquitous and can be found in a variety of lesions of various species, but again a clear cut zoonosis is not obvious with one exception to which we will return.

The classification and nomenclature of streptococci is receiving scrutiny, and changes are evident in the current edition of Bergey's Manual.[5] Suffice to say that with few exceptions there is little evidence for streptococcal zoonosis in the remaining serogroups. *Streptococcus porcinus* (Group E) is a major cause of jowl abscesses in swine. Streptococci belonging to Group G are commonly found in the respiratory and genital tract of dogs and cats and have been found in human disease as well.

The remainder of this discussion will focus on a particular organism, *Streptococcus suis*, which falls within Lancefield's serogroup D.[6] This organism was first isolated from cases of meningitis and arthritis in baby pigs from England and The Netherlands. First attempts at serological classification placed them in new groups R, S and T; however, later studies showed they belonged, in serogroup D. Two syndromes were recognized, a meningitis of very young pigs from which *S. suis* type 1 was isolated and a septicemia and meningitis of older pigs from which a serologically distinct organism (*S. suis* type 2) was found. These streptococci are now common in most major swine-rearing areas of the

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world, and several serotypes are recognized.

In the same time period, cases of meningitis in human beings were recorded from which Streptococcus suis type 2 was recovered.[7,8] Most cases have occurred in people closely associated with swine, including slaughter house workers, butchers and farmers. Skin abrasions and cuts have been the primary site of infection. A variety of clinical signs may occur concurrent with the meningitis including arthritis and petechial hemorrhage.

In spite of the frequent isolation of Streptococcus suis type 2 from swine in North America, only two cases of human disease have been recorded and these were from Ontario, Canada.[9] In a further report, S. suis type 2 was recovered from 7.0% of pigs slaughtered at a southwestern Ontario abattoir. Isolations of Streptococcus suis type 2 were made also from the hands and knives of workers, particularly at the lung evisceration station.[10]

In a sample of fifty hogs at an abbatoir in Nebraska, S. suis was found in 10 (20%) porcine tonsils. In a parallel examination, ten samplings were taken from the knife blades of eviscerators working on the throat area of the carcasses. Each knife was used to process approximately five carcasses before being swabbed, therefore, the study included approximately fifty carcasses, but not the same as those previously described. Each knife was placed in a hot water bath after the sample was collected. No Streptococcus suis was found. Obviously, this is a very small sample size, but it gives some indication that Streptococcus suis is present in slaughtered carcasses. The fact that none was present on the knives may simply reflect the small number of carcasses represented or that

the knives sampled were not used on colonized tissues. The hygienic practices in this plant and lack of human disease suggest that risk of infection has been minimized.

From the available literature we can make a few pertinent conclusions. Streptococcus suis type 2 is a relatively potent infectious and zoonotic agent in both swine and man, able to cause life threatening illness in otherwise healthy individuals. People associated with the swine industry are at a greater risk than the population in general. Good personal hygiene and conscientious attention to the use of cleaning and disinfection methods should minimize this risk. In addition, physicians and medical technologists should be apprised of this disease and the methods of recognizing the causative agent.

References

1 Lancefield, RC. A serological differentiation of human and other groups of hemolytic streptococci. J Exp Med 57, 571, 1933.

2 Mayer G. and VanOre, S. Recurrent pharyngitis in family of four. Postgraduate Med 74, 277, 1983.

3 Timoney, JF et al. The genus streptococcus, In Hagan and Bruner's Microbiology and Infectious Diseases of Domestic Animals. 8th Ed., Pg. 181.Comstock Pub., 1988.

4 Eickhoff, TC. Group B streptococci in human infection. In Streptococci and Streptococcal Diseases, Wannamaker LW and Matsen JM Editors. Pg 533, Academic Press NY 1972.

5 Rotta, J. Pyogenic Hemolytic Streptococci In Bergey's Manual of Systematic Bacteriology, pg. 1042 Vol. 2. Williams and Wilkins, 1986.

6 Elliott SD, McCarty M and Lancefield RC. Teichoic acids of group D streptococci with special reference to strains from pig meningitis. J Exp Med 145, 490, 1977.

7 Arends, JP and Zanen HC. Meningitis caused by *Streptococcus suis* in humans. Rev Infect Dis 10, 131, 1988.

8 Clifton-Hadley, FA. *Streptococcus suis* type 2 infections. Br Vet J 139, 1, 1983.

9 Sanford, SE and Tilker ME. *Streptococcus suis* type 11 - associated diseases in swine: Observations of a one-year study. J Am Vet Med Assoc 181, 673, 1982.

10 Breton J. *Streptococcus suis* in slaughtered pigs and abattoir workers. Can J Vet Res 50, 338, 1986.

CYSTICERCOSIS

J. R. Weedon, DVM, MPH, Texas Department of Health, Austin, Texas

While performing routine postmortem meat inspection procedures, a Texas Department of Health meat inspector found numerous cysts in the myocardium, diaphragm, and masseter muscles of several cattle from a West Texas feedlot. The inspector notified the supervising veterinarian, who identified the cysts as the larval stage of _Taenie saginata_. The latter was confirmed by the Parasitology Department of the College of Veterinary Medicine at Texas A & M University.

Of the 126 cattle submitted for slaughter from this particular lot, 119 were affected. In accordance with the USDA Meat Inspection Regulations, 26 extensively affected carcasses were condemned and 93 lesser-affected carcasses were passed for human food consumption after removal and condemnation of the lesions and freezing the carcasses at -10 C (15 F) for 10 days.

Sites of infection for the infected cattle were:

Masseter muscles	75%
Heart muscles	95%
Diaphragm	80%
Muscles of forelimb	40%
Round muscles	less than 10%

On the same day three USDA establishments identified rates of cysticercosis infection above 75% in cattle from the same feedlot.

Steps in the ensuing investigation included determining the sources and movements of all cattle entering the feedlot (21 different sources between 1/12/75 and 6/6/75), the sources and methods of handling all ration ingredients (milo, baled alfalfa hay, pelletized citrus pulp, gin trash, dried manure, and commercial supplements) from 9/1/74 to 6/6/75, the employees of the feedlot and their dependents (49 employees with 38 dependents) from 9/1/74 to 6/6/75, the sources and uses of the water, and the drawing and studying of several plot plans showing the important physical facilities and geographical features of the premises. Laboratory samples examined for Taenia eggs included the ration material from each feed trough, samples of all ration ingredients, sludge from cesspools associated with employee housing, fecal material found in the baled hay storage area, and three consecutive fecal samples from all employees and dependents currently employed. In addition, those employees engaged in feeding operations were tape tested. All laboratory tests for Taenia eggs were negative.

During the course of the investigation, it was finally determined that cattle arriving in the feedlot later than May 7, 1975, were not found to be infected when slaughtered. From the date of the initial diagnosis, a total of nearly 3800 cattle that were received at the feedlot on or before May 7, 1975, were found to have a rate of infection of 85%, with a 9.5% rate of condemnation. This "cut-off" date allowed us to determine that the most probable dates of infection extended from early December, 1974, through January, 1975.

During this time period, at least fourteen employees resided in a dormitory facility adjacent to the gin trash storage area with no indoor toilets. None of these employees were available for examination at the time of the investigation. It is theorized that at least one and probably several of these people were infested with Taenia saginata and, rather than utilize the outdoor toilet located in the back of the building, defecated repeatedly in the gin trash. This roughage material acted as an insulator, protecting the Taenie eggs from dessication and extremes of temperature. A massive supply of fertile Taenia eggs was accumulated in a relatively small amount of the gin trash material and, consequently, supplied a very large dose of eggs to each animal within a short feeding time span. All gin trash was fed out immediately prior to the start of the investigation and therefore not examined.

Since the outbreak, the dormitory facility has been eliminated, the gin trash storage area has been fenced off, and numerous approved outdoor toilets have been installed throughout the feedlot. There has been no recurrence of Taenia saginata cysticercosis.

EPIDEMIOLOGICAL APPLICATIONS OF A DATABASE MANAGEMENT SYSTEM FOR THE NATIONAL BOVINE TUBERCULOSIS ERADICATION PROGRAM

by
R. M. Meyer DVM, M. D. Salman DVM PHD,
and J. S. Reif DVM MS

In 1917, the United States Department of Agriculture in close cooperation with participating state animal health authorities and the United States livestock industry initiated a program to eradicate bovine tuberculosis from the nation's domestic livestock population. Over 520 million tuberculin tests in more than 33 million lots of U. S. cattle have revealed more than 4 million reactors since the eradication program started (USDA a). Literally thousands of herd investigations have been conducted as a result of tracing tuberculous animals and locating infected herds of origin.

However, bovine tuberculosis still persists at a low prevalence level. Additional tools and new ideas must certainly be infused into the program if the goal of bovine tuberculosis eradication is ever to be achieved.

An immense volume of data has been generated about infected animals, herds, and investigations since the national eradication program began. The processing of program data in most states has largely been a manual procedure, and the manual filing of historical documents may vary from state to state. Therefore, retrospective requests for epidemiological information that may be extremely useful in evaluating certain significant aspects of the program are extremely difficult if not impossible to obtain. The personnel costs alone to manually search through existing

records and compile a report would be prohibitive even though such information might be advantageous in locating infected herds and ultimately eradicating the disease.

Data that are unorganized or handled in such a way which cannot be easily referenced are severely limited in their capability of enhancing a disease eradication program. However, if data are organized, information can be obtained that should facilitate eradication activities.

No uniform, automated method of managing national program data has been available until now. In 1984, Information Management committee members attending the National Tuberculosis Eradication Program Evaluation Conference recommended that program records, program data, and reports be computerized (USDA b). In 1986, USDA's bovine tuberculosis program staff determined that in order to enhance the eradication effort, a nationwide information system should be developed to accurately process, retrieve, and more thoroughly analyze data generated by the program.

The national bovine tuberculosis staff in cooperation with systems analysts from the National Center for Animal Health Information Systems in Ft. Collins, Colorado, have recently completed a database management system to capture data generated from all aspects of the eradication program. This system is known as the Tuberculosis Information Management System (TIMS), and currently operates in a stand alone, microcomputer-based environment. The system was developed using the ORACLE relational database management system and the AT&T personal

computer.

The immediate purposes and objectives of the Tuberculosis Information Management System are to provide methods for:

1. Tracking tuberculin test and post mortem examination data;
2. Tracking epidemiological investigations of animals entering or leaving infected herds;
3. Scheduling retests of herds determined to be at high risk of acquiring tuberculosis;
4. Incorporating animal population at risk data for each study population; and
5. Producing descriptive, epidemiological reports that will allow better evaluation of program progress.

Disease surveillance procedures presently in operation need frequent reviewing regarding their effectiveness in identifying the remaining "pockets" of infection. In addition, herds involved in previous tuberculosis investigations need repeated evaluations regarding their current disease status. Several reports initially provided by the Tuberculosis Information Management System address these issues and are now discussed.

Two methods of identifying tuberculous herds involve:

- The tuberculin testing of cattle by private or regulatory veterinarians; and
- The tracing of cattle having TB suspicious lesions at slaughter to their herds of origin.

Since the number of tuberculin tests conducted annually in the United States continues to decrease, it is extremely

important that tuberculin testing be properly conducted and reported. The report entitled <u>Results of Caudal Fold Tuberculin Testing by Veterinarian</u> provides the tuberculosis epidemiologist a way to begin evaluating whether differences in response reporting exist between veterinarians. If they do, then perhaps this may be one of several factors allowing bovine tuberculosis to persist. The tuberculosis epidemiologist might hypothesize that differences in reported response rates may be due to inconsistent tuberculin testing techniques. By further stratifying this report by geographical location of each testing veterinarian, nonspecific sensitivities existing in regional or local environments can be controlled.

RESULTS OF CAUDAL FOLD TUBERCULIN TESTING BY VETERINARIAN
FOR THE PERIOD
01-NOV-87 THRU 31-NOV-8

Veterinarian Name	Vet Type	# Animals Responding To Test	# Animals Tested	Proportional Animal Resp. Rate	# Herds Responding To Test	# Herds Tested	Proportional Herd Response Rate
ARNOLD JOHN M	P	5	2500	.0020	2	25	.0800
BARNES HAROLD L	P	10	3110	.0032	6	32	.1875
TOTALS		15	5610	.0027	8	57	.1404

Figure 1
Results of Caudal Fold Testing by Veterinarian

Testing veterinarians may sometimes be placed in awkward situations based upon the reason or purpose they are called to a premises to conduct a tuberculin test. For example, a veterinarian reading a caudal fold tuberculin test on animals destined for new owners in other states may certainly feel some owner or market pressure to report a negative test. This could

certainly be so if no recent evidence of tuberculosis in the area exists, the sale transaction has already taken place, or if trucks have already been ordered to transport the animals. To evaluate the hypothesis that reporting of tuberculin responses may be influenced by the reason that the test is conducted, the Proportional TB Test Response Rates in Cattle by Reason for Test report may be used to begin the process.

Proportional Tuberculin Test Response Rates in Cattle
By Reason for Test

(TDMS207)

By: Observation_Date For the Period

01-JAN-88 THRU 21-SEP-88

REASON FOR CONDUCTING TB TEST	# CATTLE RESPONDING TO TEST	# CATTLE TESTED	PROPORTIONAL ANIMAL RESP. RATE	# HERDS RESPONDING TO TEST	# HERDS TESTED	PROPORTIONAL HERD RESPONSE RATE
1 Area Testing	2	208	0.0096	1	1	1.0000
2 Herd Accreditation or Reassr	1	350	0.0028	1	1	1.0000
3 Comply with Milk Ordinances	0	400	0.0000	0	1	0.0000
4 Sale, Show, Interstate, etc.	2	37	0.0541	1	1	1.0000
5 Import Animal Retest	1	2	0.5000	1	1	1.0000
7 Tracing - Regular Kill	2	6	0.3333	1	1	1.0000
TOTALS	8	1013	0.0079	5	6	0.8333

Figure 2
Proportional Tuberculin Test Response Rates
in Cattle by Reason for Test

Surveillance for bovine tuberculosis in slaughtering establishments is evaluated by producing granuloma submission rates for each plant. These rates are computed by counting the number of suspicious lesions or thoracic granulomas submitted by each plant and dividing by the numbers of adult and total cattle killed at each plant respectively. The Granuloma Submission

Rates by Slaughtering Establishment report can be generated on a quarterly or semi-annual basis so that plants needing a boost in their rate of granuloma submissions can be visited promptly.

TUBERCULOSIS INFORMATION MANAGEMENT SYSTEM
Granuloma Submission Rates
by Slaughtering Establishment
(TIMS208)

For the Period
01-JAN-88 Through 15-MAY-88

Estab Nr	Establishment Name	# Adult Cattle Submissions	Total # Cattle Submissions	# Adult Cattle Killed	Total Cattle Killed	Rate Of Submission (per 1000 Hrd) Adult	Total
462A	Donoho Meats	1	1	222	444	4.5045	2.2523
362A	Monfort Beef Packers	0	1	200	400	.0000	2.5000
	TOTALS	1	2	422	844	2.3697	2.3697

Figure 3
Granuloma Submission Rates by
Slaughtering Establishment

As the prevalence of bovine tuberculosis further decreases, the tuberculosis epidemiologist may wish to evaluate certain aspects of the TB eradication program on a county by county basis. Information regarding the amount of tuberculin testing being conducted in each county may be helpful in evaluating if surveillance is adequate. In addition, the epidemiologist may also wish to evaluate if differences in tuberculin response rates exist between counties or if certain counties have been involved in a disproportionate number of tuberculosis investigations over a longer period of time. In either case, information that tends to indicate that descrepancies exist may certainly justify the use of special area testing procedures.

The report entitled Estimated County Rates for Cattle Responding to the Caudal Fold Tuberculin Test provides estimates

of county rates for animals responding to the caudal fold tuberculin test.

ESTIMATED COUNTY RATES FOR CATTLE RESPONDING TO THE
CAUDAL FOLD TUBERCULIN TEST
FOR THE PERIOD
01-NOV-87 THROUGH 01-DEC-87

County Name	# Cattle Responding To Test	# Cattle Tested in the County	# Cattle in County	Est. Animal Response Rate	Proportion of Cattle Tested in the County
Adams	25	1000	5000	.005	.2000
Barber	25	2000	5000	.005	.4000
Campbell	25	1000	10000	.0025	.1000
Totals	75	4000	20000	.0038	.2000

Figure 4
Estimated County Rates for Cattle Responding to the Caudal Fold Tuberculin Test

The estimated rate is based upon the total number of cattle in the county determined to be at risk of becoming infected, and is calculated by dividing the number of cattle responding to the test by the cattle population in each county. The column called "Proportion of Cattle Tested in the County" allows an evaluation of the amount of surveillance testing being conducted. Estimated animal rates may be more directly compared between those counties having roughly equivalent" Proportions of Animals Tested" figures since the denominators of each estimated rate are based on animals at risk rather than on total animals tested. Although such estimated rates are not randomly based, they are convenient and should provide the epidemiologist some indication of differences existing in tuberculin response rates between counties.

The TIMS report, <u>Investigation Rates by County</u>, provides investigation rates for each county in which investigations have been recorded. By dividing the number of cattle herds

investigated in each county during the period of time specified by the number of cattle herds in each county, this report may be produced and used to evaluate which counties may need additional disease surveillance.

TUBERCULOSIS INFORMATION MANAGEMENT SYSTEM
Investigation Rates by County
(TIMS209)

For the Time Period
01-JAN-88 Through 15-MAY-88

County Name	Number Of Cattle Herds Investigated	Number Of Cattle Herds In County	Investigation Rate
Larimer	1	10	.1000
Weld	4	20	.2000

Figure 5
Investigation Rates by County

Since the beginning of the bovine tuberculosis eradication effort, thousands of herds have been involved in tuberculosis investigations. Some herds have been investigated several times without establishing direct, positive proof that M. bovis infection exists even though available evidence seems to point to its probable existence. Long term surveillance in these herds is critical. However, as time passes and program people change jobs or retire, many herds have seemingly become forgotten. TIMS is designed so that such herds will not be forgotten, but can be maintained on high risk herd lists to insure future herd reevaluations. The TIMS report entitled Tuberculosis Investigations Involving a Specified Herd allows the system user to ask the important question, "Has Herd X ever been involved in a bovine tuberculosis investigation before?" If Herd X has, a report detailing the type of investigation previously involved is

generated. The herd may then be immediately scheduled for examination.

TUBERCULOSIS INFORMATION MANAGEMENT SYSTEM
Tuberculosis Investigations
Involving a Specified Herd
(TIMS204)

State	Herd Id	Herd Name	Contact City	Operation Type	Size
CO	G234-60	Greeley Feedlot	Greeley		

Case Number Investigation Number Sequence Number	Investigation Initiation Date	Type Of Investigation	Investigation Closure Date	Reason For Closure Investigation	Assigned Vet Code
88-0013-0000-05.00	12-APR-88	63S	12-MAY-88	10	F12345
87-539-0008-02.40	12-MAY-88	64B	15-APR-88	20	F23456
87-539-0002-01.00	12-MAY-88	64A	15-APR-88	11	F23456
88-0133-0000-03.00	12-MAY-88	63S	12-MAY-88	10	F12345

Cases Initiated by the Specified Herd

CASE NUMBERS	INVESTIGATIONS INITIATED	CASE REMARKS
88-1297	12-MAY-88	Area Test 2-13-88 (CC obs)

Figure 6
Tuberculosis Investigations Involving
A Specified Herd

It is not realistic to believe that improved funding or increased personnel ceilings to test more cattle or more thoroughly investigate suspicious herds will occur in the foreseeable future. In order to make further gains we must better utilize the tools now available. Dr. W.H. Feldman, in his article, "Yesterday's Triumphs: Today's Problems" emphasizes the need to feed enthusiasm, energy, adequate funds, and <u>new ideas</u> into an eradication program (Feldman). Better organization and use of the data now available most certainly is a new idea, and can surely be an effective tool in the eradication effort.

REFERENCES

Feldman, W. H. "Yesterday's Triumphs; Today's Problems," Jour. of the American Medical Association. 194 (1965): 33-36.

USDA/APHIS/Veterinary Services. Cooperative State-Federal Bovine Tuberculosis Eradication Program Statistical Tables of Fiscal Year 1983. (1984): 3-10.

USDA/APHIS/Veterinary Services. Tuberculosis Eradication Program Evaluation Conference June 5-7, 1984, College Park, Maryland. (1985): 1-72.

AUTOMATED TRACEBACK SYSTEM FOR CATTLE

Michael Pavlick, DVM, USDA/APHIS/VS, Renfro Valley, KY

A data base in concern with a word processor is used to establish a centralized file of all section tracebacks and produce working documents:

A. Neat pre-addressed letters to the last known purchasers containing cattle identification, date, and place of purchase. There are spaces provided for entering the disposition of the animals. The address in the heading shows through a standard window envelope and a pre-addressed, pre-stamped envelope is included for the reply.

B. A work sheet to be used at the stockmarket or on the farm when making enquiries.

C. A second, stronger letter to purchasers requesting information much in the style of commercial debt collection.

D. Closed cases are retained in the data base, but ignored unless specifically called up.

In practice the VMO makes the original entries into the data base and updates it as information is gathered. From the word processor menu one selects the documents needed and the rest is automatic.

For example if you are going to visit a stockyard, simply ask for a work sheet listing cattle sold through that yard and the program will cheerfully produce an updated form listing the current information on all (or selected) traces from that yard.

I have found the following advantages:

A. The records which are received at random internals are in a centralized easily accessible location.

B. About 60% of the first letters bring a response which closes the case.

This application meets my criteria for automated data systems:

A. It is useful and efficient, actually saving time and effort.

B. The user needs no special training. A one or two hour introduction will enable any field VMO to use it (user friendl, if you will). I have used macros to save the used from wading through menus and commands to get the job done.

C. The data is transportable, that is, anyone in APHIS can read this information into their IBM compatible system and share it.

My system has one serious fault in that it does not use an agency standard program. I had planned to put this application in the Oracle data base management program, but Oracle has some problems on field machines. However, the data are transportable to Oracle and other data base managers so nothing will be lost. It could, for example, be sent on line to the area minicomputer.

This is an area where we will be in serious trouble soon, my visit to NAHMS confirms that they are falling into a well-documented syndrome common to start up operations.

A Profile of Epidemiological Literature

Edwin I. Pilchard, D.V.M., Ph.D.

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U. S. Department of Agriculture

Symposium '88 on Veterinary Epidemiology, Zoonoses, and Economics
American College of Veterinary Preventive Medicine
and
U.S. Department of Agriculture, Animal and Plant Health Inspection Service
Bethesda, Maryland

September 26-27, 1988

Introduction. The profile of epidemiological and economic literature given in this report briefly summarizes some online searches recently completed to compare the quantity of literature retrievals from the Veterinary Services EMERPRO data base (Emergency Programs, Animal and Plant Health Inspection Service, U.S. Department of Agriculture) to other literary data bases, in locating information on veterinary epidemiology and economics.

Background. In 1979, D. E. Gray (Commonwealth Agricultural Bureaux, England) analyzed the performance of five major data bases for veterinary literature: BIOSIS (Biosciences Information Service, Biological Abstracts), CAIN (Cataloguing and Indexing System, National Agricultural Library: NAL), CAB (Commonwealth Agricultural Bureaux, England), MEDLARS (Medical Literature Analysis and Retrieval System), and PASCAL (Programme Applique a la Selection et la Compilation Automatique de la Litterature). His calculated rates of retrieval for information relevant to a set of questions from veterinarians ranged from 23 to 33 percent (no. relevant articles/no. articles retrieved=rate of retrieval). From this analysis, one might expect to find some needed veterinary information in one out of 3 or 4 articles found through an online retrieval from one of the tested data bases. Gray concluded that the veterinary profession was being well served by the online literarary systems then available.

Gray's study followed a 1978 report by the Commission of the European Communities (CEC) (H. Brodauf, W.D. Hoffmann and J.H.T. Klawiter-Pommer. Searching the Veterinary Literature Retrospectively, 56 pages, Oxford Microform Publications, Ltd., Oxford, England), in which a set of 90 questions from veterinarians in 9 European countries were used to make searches of 10 different online data bases. The data bases were evaluated for quantity of retrievals, precision, and recall. In the CEC study, CAB, and CAIN were ranked highest for effectiveness, according to the point system on which the investigators analyzed their data.

Because of the wide range of subject matter covered by both the Gray and CEC studies and their omission of the subject fields of epidemiology and economics, it was not possible to determine the relative performances of the studied data bases for veterinary epidemiology and economics.

The data bases selected for study in this report (CAB Abstracts, AGRICOLA, and EMERPRO) were known to have significant numbers of citations on veterinary epidemiology and economics, but the rates of relevant retrievals were not known. AGRICOLA, with about 500,000 citations in the areas of animal health and veterinary sciences, has been maintained by the National Agricultural Library since 1970. CAB Abstracts regularly scans over 85,000 journals in 37 different languages, and has about 161,000 citations in the areas of animal health and veterinary sciences. It has been maintained by the Commonwealth Agricultural Bureaux since 1972. In contrast, EMERPRO has about 65,000 citations in the areas of animal health and veterinary sciences. EMERPRO has been maintained by the Veterinary Services (VS) branch, Animal and Plant Health Inspection Service, since 1973. VS staff regularly select articles from NAL searches of the world literature and other secondary sources, for relevancy to VS programs, and acquires articles for storage on microfilm, regardless of publication date. EMERPRO is designed primarily as an automated index to VS microfilm holdings of original English language articles and translations. Complete citations and NAL call numbers that are included in EMERPRO also afford access to holdings in conventional libraries.

The EMERPRO data base is intensively cross-indexed under a specialized contract with professional indexers, for access to animal health and veterinary medical information. Indexing is focused on 40 diseases of livestock and poultry, veterinary entomology, epidemiology, disposal of infectious agents, cleaning and disinfecting, and veterinary ecomomics.

Approach. After writing an outline of this report, counts were made of total citations available on the selected subject matter in AGRICOLA (Agriculture On-Line Access (formerly CAIN), National Agricultural Library, U.S. Department of Agriculture), CAB ABstracts, and EMERPRO. A table and six bar graphs were then generated, comparing the performance of the three data bases in locating literature on veterinary epidemiology and economics.

Results. The following table and graphs present a profile of a quantitative comparison of the three selected data bases for their effectiveness in locating literature related to veterinary epidemiology and economics.

(Table. Data base holdings - September 1988.)

AGRICOLA holds 500,000 citations on animal health and veterinary sciences, 5,151 on epidemiology, and 6,524 on economics. CAB Abstracts holds 161,000 citations on animal health and veterinary sciences, 6,611 on epidemiology, and 10,034 on economics. EMERPRO is dedicated to animal health and veterinary sciences for a selected set of diseases and arthropod pests, and holds 65,399 citations of which 5,145 contain information on epidemiology and 3,515 contain information on economics.

Figure 1. Brucellosis Epidemiology. (see attachment)

A search for citations on brucellosis epidemiology counted 216 in AGRICOLA, 80 in CAB Abstracts, and 792 in EMERPRO.

Figure 2. Brucellosis Economics. (see attachment)

A similar search on brucellosis economics counted 89 citations in AGRICOLA, 23 in CAB Abstracts, and 792 in EMERPRO.

Figure 3. FMD Epidemiology. (see attachment)

When the same subject categories were applied to foot-and-mouth disease (FMD), there were 68 epidemiology citations in AGRICOLA, 795 in CAB Abstracts, and 866 in EMERPRO.

Figure 4. FMD Economics. (see attachment)

The search for citations on FMD economics counted 5 in AGRICOLA, 21 in CAB Abstracts, and 913 in EMERPRO. Apparently, the people who indexed articles for AGRICOLA and CAB Abstracts did not place as much emphasis upon disease economics as did the indexers for EMERPRO.

Figure 5. Bovine Mastitis. (see attachment)

Because the U.S. Department of Agriculture has no program for the control of bovine mastitis, we have not collected the literature on this subject for the EMERPRO data base. Nevertheless, there were 222 citations on bovine mastitis in EMERPRO, most of them related to brucellosis. In contrast, there were 929 citations on bovine mastitis in AGRICOLA, and 2,058 in CAB Abstracts.

Figure 5. Akabane and Akabane Pathogenesis. (see attachment)

Not unexpectedly, EMERPRO was found to have marked advantages over AGRICOLA and CAB Abstracts in locating citations for the diseases on which we are collecting the world literature. For example, about 136 published articles on Akabane disease of cattle exist. This disease has been reported from Japan, Australia, and the Middle East. Citations for all of these articles are in EMERPRO, and the articles are on VS Data Bank microfilms. AGRICOLA lists 78 Akabane citations, and CAB Abstracts lists 63. When the Akabane search was truncated by adding a Boolean "and," and the keyword "pathogenesis," EMERPRO had 28 citations, CAB Abstracts had six, and AGRICOLA had two.

Summary. Marked differences were found between three literary data bases--CAB Abstracts, AGRICOLA, and EMERPRO, when compared for their holdings in veterinary epidemiology and economics. The first two of these data bases had been ranked highest for their effectiveness for veterinary subject matter in a 1978 CEC study. In the brief study reported in this paper, EMERPRO contained more citations on veterinary epidemiology and economics than either CAB Abstracts or AGRICOLA, when the searches were limited to disease subject headings under which EMERPRO specializes.

When the key words "epidemiology" and "economics" were searched regardless of disease subject heading, the totals were similar among the three data bases. However, the comparison in this instance is not valid because CAB Abstracts and AGRICOLA cover the entire range of agricultural subject matter, whereas EMERPRO specializes in about 40 different disease subjects for livestock and poultry, plus veterinary entomology.

The profile presented in this report is intended to illustrate the importance of selecting the best available data bases for the subject matter in which you are interested. As an example, EMERPRO is shown as a powerful tool for use in animal disease emergencies, to rapidly search the world literature on foreign diseases and several domestic diseases of livestock and poultry.

Recommendation. When contemplating a search for needed literary information, follow these steps:

1. Write a description of what is needed, including appropriate key words.

2. Select at least two data bases that are known to contain the kinds of information needed.

3. Evaluate the results of your search, and, if not satisfied,

4. Consult an expert in the subject matter field of interest.

Subject	Databases		
	AGRICOLA	CAB Abstracts	EMERPRO
Animal Health	500,000	161,000	65,399
Epidemiology	5,151	6,611	5,145
Economics	61,524	10,034	3,515

Table. Database Holdings – September 1988: Number of citations

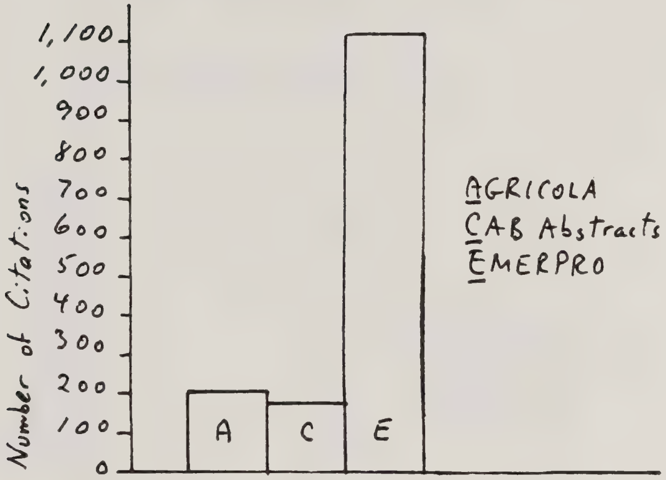

Figure 1. Brucellosis Epidemiology

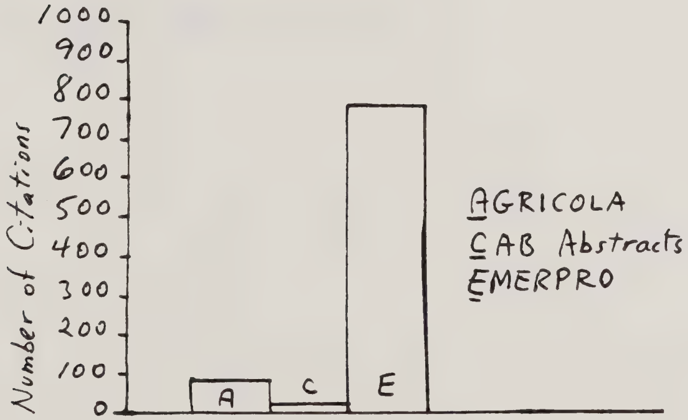

Figure 2. Brucellosis Economics

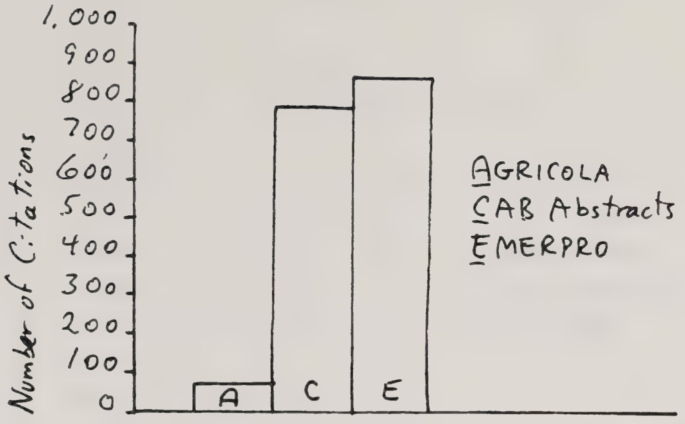

Figure 3. FMD Epidemiology

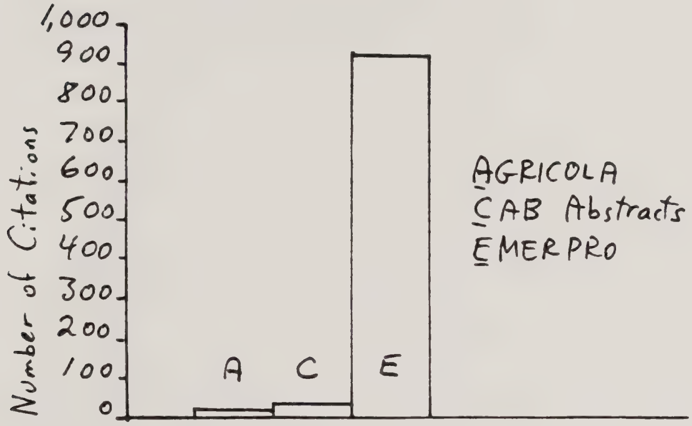

Figure 4. FMD Economics

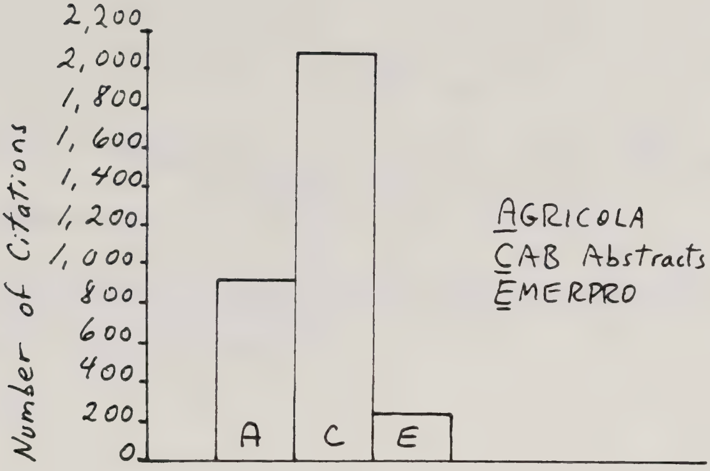

Figure 5. Bovine Mastitis

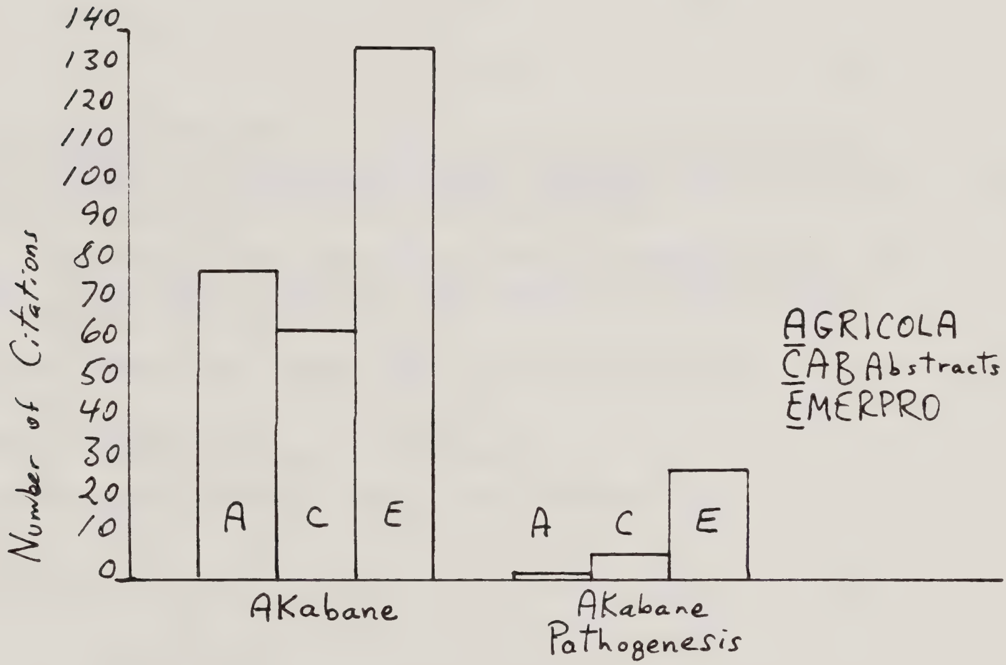

Figure 6. AKabane and AKabane Pathogenesis

Information Request
Work Sheet

Requested by: Name______________________________ Date:________________
Address______________________________ Telephone:(   )__________
____

Date needed:____

Please describe the topic on which you want information. Be specific -- include synonyms and closely related terms, supply keywords, and define any words that have special meaning in your request. Also, identify words or phrases you wish excluded.

References already located which are relevant:

Would you prefer (check one)
___a comprehensive search that may include some references not relevant?
___a narrow search that may miss some relevant references but will retrieve fewer irrelevant references than a comprehensive search?

Number of references: Please indicate the number of references wanted. The searcher will use this as a guide but cannot guarantee the actual number that will be obtained. (circle one) Up to 25 Up to 100 Up to 200

Time period desired: (Most online bases only go back to the late 1960's.)_____

Language: English only?____ Other?____

Are there particular authors in which you are interested?

Other instructions:

Transmit or send the above information to: VS Data Bank, IEEP, PPD, VS, APHIS, Room 740 Federal Building, Hyattsville, MD 20782, FTS 436-8687.

Alphabetical List of Emerpro files

Disease Files	Initials	Code no.
African Horsesickness	(AHS)	025
African Swine Fever	(ASF)	006
Akabane	(AK)	019
Bluetongue, Epizootic Hemorrhagic Disease, Ibaraki	(BT)	012
Borna Disease	(BD)	034
Bovine Babesiosis, Porcine Babesiosis	(BB)	023
Bovine Parafilariasis	(BP)	039
Brucellosis	(BR)	015
Contagious Agalactia	(CA)	036
Contagious Equine Metritis	(CEM)	018
Contagious Pleuropneumonia	(CP)	026
East Coast Fever	(ECF)	021
Entomology	(ENT)	100
Ephemeral Fever	(EF)	014
Equine Encephalosis	(EE)	038
Foot-and-Mouth Disease	(FMD)	001
Fowl Plague, Avian Influenza	(FP)	020
Glanders	(GL)	028
Heartwater	(HW)	022
Hog Cholera	(HC)	004
Infectious Petechial Fever	(IP)	029
Japanese Encephalitis	(JE)	043
Louping Ill	(LI)	032
Lumpy Skin Disease	(LS)	024
Melioidosis	(ME)	033
Nairobi Sheep Disease	(NS)	031
Nematodiasis	(NE)	041
Newcastle Disease	(ND)	002
Pseudorabies	(PR)	017
Rift Valley Fever	(RVF)	010
Rinderpest, Pest of Small Ruminants, Kata	(RP)	016
San Miguel Sea Lion Virus	(SMSV)	007
Screwworm Myiasis	(SM)	040
Sheep Pox, Goat Pox	(SP)	027
Sweating Sickness	(SS)	030
Swine Vesicular Disease	(SVD)	003
Teschen Disease	(TD)	035
Trypanosomiasis, Dourine	(TR)	005
Tuberculosis	(TB)	042
Venezuelan Equine Encephalomyelitis	(VEE)	009
Vesicular Exanthema	(VE)	008
Vesicular Stomatitis	(VS)	013
Visna, Maedi	(VI)	011
Wesselsbron Disease	(WD)	037

Non-Disease Files

Biometrics	(BM)	201
Cleaning and Disinfecting	(CD)	202
Disposal (includes euthanasia)	(DI)	203
Economics	(EC)	204
Epizootiology	(EP)	205
Miscellaneous	(ML)	206

Veterinary Services Data Bank
VS,APHIS,USDA, Room 741 Federal Building
Hyattsville, MD 20782 (301-436-8687)

September 1988

Patterns of Infestation with the Tropical Bont Tick, Amblyomma variegatum, within St. Croix, U.S. Virgin Islands, and Puerto Rico.

Bob H. Bokma, DVM, MPVM, Diplomate ACVPM

Abstract:

Experience since 1967 with the tropical bont tick, Amblyomma variegatum, on St. Croix, U.S. Virgin Islands, and on Puerto Rico and its island municipalities, Vieques and Culebra, is reviewed and contrasted with that of Boophilus microplus, the tropical cattle tick. Within this geographical setting, infestations with Amblyomma variegatum have varied from single tick collections of males on just one animal to marked infestations on all animals in a herd in which serious livestock mortality has been described. Foci of infestation have been limited to relatively small groups of contiguous herds in rural areas. Collections of ticks have occurred principally on cattle; however, ticks have been collected routinely from horses, goats, and dogs, and occasionally from sheep, chickens, cattle egrets, and mongoose.

Success in the control and elimination of established infestations has varied with the ability to follow an active and effective program of quarantine of animals on infested premises, biweekly treatment of all domestic animals on infested premises, controlled removal of host-species animals, and surveillance for new infestations.

Introduction:

The 3-host African-origin tropical bont tick (TBT), Amblyomma variegatum (Fabricius 1793), has been present in the Caribbean since the early 1800's. (Morel 1966; Uilenberg et al 1984; Barre et al 1987) The spread of this 3-host tick from early established infestations on Guadeloupe and later Antigua and St. Kitts to many islands, including St. Croix of the U.S. Virgin Islands, the main island of Puerto Rico, and its island municipality, Vieques, has been described by several authors. (Strickland et al 1976; Uilenberg et al 1984; Birnie et al 1985; Barre et al 1987, Garris et al in press) Puerto Rico's second island municipality, Culebra, has also been discovered to be infested. In addition to the TBT infestation, in 1978 Puerto Rico became reinfestated with the 1-host tropical cattle tick, Boophilus microplus, after a period of some 24 years of free status following eradication. Both Puerto Rico and the U.S. Virgin Islands are currently under Federal quarantine for Boophilus microplus. (USDA National Tick Surveillance Program, Annual reports; USDA APHIS VS, San Juan)

Immature stages of the TBT feed on smaller mammals or birds and the adult stage is typically found on livestock species, with cattle as a preferred host. The general biology of this tick and the peculiarity it presents in the Caribbean are further described by other authors. (Hoogstral 1956;

Garris 1984) In the Caribbean, infestations of the tick on ruminant species, particularly cattle, have been associated with high mortality due to cutaneous dermatophilosis, which is associated with infection by the aerobic actinomycete, Dermatophilus congolensis. (Butler 1975; USDA 1978; Thoen et al 1980; Burridge et al 1984) In addition, the disease heartwater, an infection with the rickettsia, Cowdria ruminatium, has been described in ruminants on the 3 islands of Guadeloupe, Marie Galante, and Antigua. (Perreau et al 1980; Uilenberg et al 1984; Birnie et al 1985)

The elimination of TBT infestations from St. Croix in the late 1960's and later the main island of Puerto Rico and Vieques in the early 1980's has been described. (Hourrigan et al 1969; Graham et al 1977; Garris et al in press) While these efforts are considered successful, an infestation of the TBT on Culebra in 1985, an reinfestation on St. Croix in 1987, and the occasional findings of solitary male adult ticks on St. Croix and Puerto Rico have been disturbing.

The intent of this paper is to review the pattern of infestation presented by the TBT over time on St. Croix, on Puerto Rico, on Vieques, and the recent infestation on Culebra, and contrast this with the very different infestation pattern presented by the tropical cattle tick, Boophilus microplus.

Infestation History:

I. St. Croix, U.S. Virgin Islands (Table 1)

The first report of Amblyomma variegatum on St. Croix was from an on-farm collection made in August 1967. A total of 6 contiguous premises were involved, in and around the Estate Prosperity area near Frederiksted, which is located on the western end of the island. There is no evidence presented as to the source of the infestation. The last ticks collected from this focus were larval TBTs from a mongoose in April 1968. The island was declared free in 1970, after a 2-year period of treatment and quarantine.

A collection of a single TBT male from a bull at the abattoir in August 1969 is also recorded. No infested animals were found on tracing to the farm of origin, located 14 miles from the previous focus in Frederiksted.

Another abattoir collection of a male TBT is reported for March 1971. This was from a sheep and investigation revealed 2 male TBT collections from a cow and another sheep on the farm of origin at Estate Betty's Hope. Two additional farms, adjacent to each other and located at Estate Grove Place, which is near the previous farm, were subsequently found in 1972 to be infested. TBT ticks were collected through 1974. Treatment activities were conducted on 11 premises through 1974 and were successful in eliminating this smaller focus. Conjecture at the time was that these latter infestations may have been related to the original 1967 focus, located some 8 miles away. (Department of Economic Development and Agriculture, Veterinary Services (DED & A VS), St. Criox; USDA National Tick Surveillance Program, Annual reports)

There is no further record of TBT identifications from St. Croix until November 1985. One male TBT tick was encountered on a horse in the Estate River area, approximately 5 miles west of Fredericksted. No source of infestation is described. Rigorous follow up surveillance of this premises and adjacent farms did not confirm any further infestation. Adult female ticks were never found. (DED & A VS, St. Croix; USDA National Tick Surveillance Program, Annual reports)

In July 1987, males and females of the TBT were discovered on horses and beef cattle at Estate Sion Farm, located in the center part of the island. The initial infestation involved a 31-acre farm of cattle, horses, swine, dogs, and chickens. The owners reported infestation of cattle, horses, and dogs, as well as heavy mortality in cattle, apparently due to dermatophilosis. Marked clinical cases of the disease were present in a few remaining head of Holstein and Senepol cattle. No source of infestation has been established. The infestation has involved only 2 contiguous private properties and adjacent U. S. National Forest Service property. On the initially discovered premises, various stages of ticks were collected from cattle, horses, and a mongoose. On the other properties, single nymphal ticks were collected from a horse and from a free-roaming chicken. There have been repeated sightings of deer on the infested areas. The last TBT collection was in December 1987. (DED & A VS, St. Criox; USDA Science and Education Administration, Agricultural Research Service, St. Croix; USDA APHIS VS San Juan)

II. Puerto Rico (Table 2)

Cidra-Cayey focus (1974-1982)

The first reported findings of Amblyomma variegatum on Puerto Rico were from the central mountainous and generally humid municipality of Cidra in April 1974. A USDA survey in June 1974 established that the infestation was limited to the 2 center-island municipalities of Cidra and Cayey. The infestation in Cidra was limited to the Rio Abajo community. In Cayey, infested farms were found in the Beatriz, Guavate, Vega I, and Vega II communities. (Strickland et al 1976; Garris et al in press; USDA APHIS VS San Juan)

The infestation was confirmed on 23 premises out of the 313 premises surveyed in a total of 12 square miles. Infested farms were usually adjacent to other infested farms. Initial findings were from cattle, predominately beef; however, 1 premises was also described in which oxen had recently been removed and only a dog was found to be infested. At the time it was conjectured that the infestation had probably been present for at least 2 1/2 years in the Guavate, Cayey area. (USDA 1978; USDA APHIS VS, San Juan)

No source of infestation was ever determined. The spread of infestation between farms was attributed to movements of cattle by at least 1 specific dealer, of oxen between farms, and of dogs; however, it has not been possible to rule out either bird or mongoose movements. (USDA National Tick Surveillance Program, Annual reports; USDA 1978; USDA APHIS VS, San Juan)

Beginning in 1974, quarantine and weekly hand-held spraying activities were conducted on the infested premises and legislative authority and funding for an eradication program were sought. Due to limitations in funding and support, a continued eradication program was not possible. Treatment and quarantine enforcement were gradually discontinued. Program surveys demonstrated that by 1975 there were 51 infested premises. In 1976, 67 infested farms in 4 municipalities are described. In 1977, this had further increased to 89 infested farms in 6 municipalities, and by July 1978, of over 5,000 premises surveyed in 625 square miles, there were 116 infested premises in 8 municipalities. Of these 8 affected municipalities, 4 had only 1 infested farm each. (Table 3) Ticks had been observed infesting cattle, swine, goats, horses, and dogs.

Dermatophilosis was described as a serious problem in affected herds. This infection was found in 59 of the first 92 herds discovered and in 11, the infection was characterized as severe. In the affected herds, 316 of a total 1,386 cattle were infected. (USDA National Tick Surveillance Program, Annual reports; USDA 1978; USDA APHIS VS, San Juan; Garris et al in press)

A USDA mathematical model predicted that with no control, the annual rate of increase in the number of infested premises could continue at 30 % and that annual beef and dairy production losses could reach $9.3 to $13.0 million. (USDA 1978) (Table 3)

With the reinfestation of Puerto Rico by the tropical cattle tick, Boophilus microplus, in late 1978, and the subsequent availability of funds, survey and eradication efforts against the TBT were again initiated in April 1981, and a field office was established at Cidra. Many previous infestations in the Cidra-Cayey focus were not confirmed on surveys conducted after April 1981, usually due to voluntary depopulations of infested areas by owners because of severe livestock mortality and to the resultant dying out of the tick. However, by September 1982, a total of 108 predominately beef farms, containing some 2300 animals, including 1 dairy herd, as well as some horses, sheep, and goats, were confirmed to be infested in 6 municipalities and had been incorporated into the eradication program based at Cidra. While 1 of the criteria used to include premises as infested was that at least 1 TBT of any life stage had been detected on animals on the premises, the vast majority of these herds had demonstrated more significant infestation. (USDA APHIS VS, San Juan)

Infestations were confirmed in Cidra (76 premises), Naranjito (1), Cayey (4), Aguas Buenas (6), Comerio (19), and Aibonito (2). (Table 2) While these municipalities are contiguous, individual foci of infestated premises were generally clustered in relatively small areas of the municipalities. Movements of cattle, including oxen, and of horses by livestock owners or dealers were again considered the source for new infestations, encountered after April 1981.

No TBTs have been collected from the Cidra-Cayey focus since September 1982. All treatments in the Cidra treatment area had been discontinued by March 1984 and the final quarantines were released in July 1984. (Suthern et al 1984; Garris et al in press; USDA National Tick Surveillance Program, Annual reports; USDA APHIS VS, San Juan)

Cabo Rojo focus (1980-1985)

In the southwestern and generally arid municipality of Cabo Rojo, TBTs were first collected in August 1980 and only 1 infested premises was encountered. During the subsequent TBT eradication efforts in Cabo Rojo, which were delayed until February 1982 and ended with incorporation of the area into the Boophilus microplus eradication program in 1987, a total of 30 premises involving beef cattle, horses, and goats were eventually included in the eradication protocol. The last TBT collections were in June 1985. Premises were generally found to be contiguous but distributed within the municipality in 2 communities, Guaniquilla and Llanos Costa. Movements of livestock by dealers have been considered the source of infestation for this focal area and spread was attributed to movement of livestock and free-roaming animals, as well as to fenceline spread. (USDA APHIS VS, San Juan)

Ponce focus (1981-1984)

In the southern, arid municipality of Ponce, TBTs were first collected in April 1981. During the subsequent TBT eradication efforts, beginning in September 1981, and terminating sucessfully in May 1986, a total of 23 premises in the Coral Viejo, Magueyes, Marueno, Quebrada Agua, and Madrigal areas of the municipality were included in the eradication protocol. These farms, many of which were directly contiguous, included beef cattle, horses, and goats. The last collection was in December 1984. As in the Cabo Rojo case, movements of livestock by dealers have been considered the source of infestation for this focal area. Spread was similarly attributed to movement of livestock and free-roaming animals and to fenceline contact with infested premises. (USDA APHIS VS, San Juan)

Incidental findings

Reports of incidental findings of single male TBTs in areas away from the TBT foci were infrequent for the period from 1981 to 1984. The majority of herds encountered with a single TBT were in the known focal areas and were placed under quarantine and treatment.

Since 1984, there have been 4 findings. One male tick was collected in May 1985 on a dairy animal in the northern municipality of Quebradillas. In May 1988, 1 male tick was collected from a beef animal in the Callejones community in Lares. In August 1988, 2 male TBTs were discovered on beef animals in the Pueblo Afuera community of Rincon in western Puerto Rico.

Dispite intensive searches, no other findings have occurred in these herds nor are they apparently related with each other or past herds. The herds were placed under treatment as a precautionary measure. (USDA APHIS VS, San Juan)

III. Vieques (1980-1986)(Table 4)

The island municipality of Vieques was first found to be infested with the TBT on 1 premises in October 1980. The TBT eradication efforts did not begin until February 1982 and were concluded successfully after February 1986, when the last positive collection of a single male TBT occurred.

A total of 24 contiguous premises in only 1 community (Martineau) and involving predominately beef cattle and horses were eventually included in the eradication protocol. As in the both the Cabo Rojo and Ponce cases, movements of livestock by dealers, in this case by ferry, have been considered the source of infestation for this focal area. Livestock and free-roaming animal movements and fenceline exposure to infested premises has been considered the cause for spread between farms.

IV. Culebra (1985-present)(Table 4)

The island municipality of Culebra was found infested when TBTs were collected in September 1985. Whereas 2 premises were originally found to be infested, 7 beef farms with some horses present in only 1 focus located in the Fraile/San Isidro area were found to have TBT in 1988. Problems in accomplishing regular treatments have occurred, but renewed efforts at systematic treatments or obligatory removal of susceptible animals from known infested farms were instituted in January 1988. Five of the infested farms have been vacated. Treatments are expected to last through 1990. Similar to the St. Croix situation, deer exist on Culebra and their role in dissemination of the TBT, as yet, is undetermined.

Discussion:

The treatment programs used in St. Croix during the late 1960's and in Puerto Rico have previously been described. In St. Croix, the original program consisted of quarantine; intensive surveillance; control of wildlife (deer, mongoose, birds); weekly and later biweekly acaricide dip or spray treatments of livestock and dogs (0.125% coumaphos) or dustings of cats and chickens (5% carbaryl dust); and 12 aerial or ground treatments with sprayable carbaryl of infested areas. The 2-year treatment program commenced in September 1967 and was continued until May 1970 due to interest in Boophilus microplus control. (Hourrigan et al 1969; Graham et al 1977; USDA National Tick Surveillance Program, Annual reports)

The current eradication effort in St. Croix has included quarantine of all animals and pastures; biweekly inspection and acaricide treatment (0.125% coumaphos) of livestock and dogs; brush clearing; trapping of, inspection for ticks on, and elimination of free-roaming chickens and mongoose; the treatment of and surveillance for ticks on animals on all immediately adjacent premises; and increased island-wide surveillance for TBT. Plans are to continue treatments for at least 18 months and until such time no ticks are collected for at least 6 months (DED & A VS, St. Criox; USDA APHIS VS San Juan)

In Puerto Rico and Vieques, the program consisted of routine quarantine, with animal movements permitted, if the animals were free of ticks and had been treated, to slaughter, or occasionally for horses and oxen, between like-infested farms; a reduction in number of free-roaming animals (chickens and dogs); a minimal 18-month program of inspections and spray treatments of all ruminant and equine species with acaricides (0.25 % coumaphos or 0.025 % amitraz, with occasional use of 0.055 % permetrin) on usually a biweekly schedule; and thereafter, if no ticks had been found for at least 6 months, a 6-month program on a biweekly schedule of inspections with no treatments. Treatments were suspended and quarantines were released in blocks of contiguous herds, when all herds met the minimal requirements. (Suthern et al 1984; Garris et al in press; USDA National Tick Surveillance Program, Annual reports) The current program in Culebra stresses quarantine and treatment or removal of livestock from infested areas. (USDA APHIS VS, San Juan)

The findings of isolated male TBTs, without further evidence of infestation, in areas separated from the known foci of infestation, is presumably due to the movement of TBTs on migratory or emigrating birds, such as the cattle egret (Bubulcus ibis), or on small domestic mammals. Further discussions of the biology of the TBT, the spread of the TBT on birds and livestock and of the diseases transported by the TBT from one focus to another, and implications in eradication programs are available or in press. (Garris 1984; Barre et al 1987; Garris 1987; Barre et al in press)

The original infestations of TBT on St. Croix, Puerto Rico, and possibly Culebra were presumably due to movement of the TBT on birds or small- to medium-sized mammals, such as dogs or goats. The case for goats being the source for either St. Croix or Puerto Rico is especially weak, because of the tick control restrictions on international and interstate livestock movements. The establishment of TBT in subsequent foci on Puerto Rico, on Vieques, and possibly on Culebra was due to livestock movements, possibly illegal, from infested areas.

Also of interest is that in August 1983, a single semi-engorged female Amblyomma cajennense (F.), the Cayenne tick, was collected from a bull in the Jaguey community of Aguada, located at the western tip of Puerto Rico. This tick was originally mistaken for a TBT and has been the only such collection. After extensive animal inspection work, the origin and mechanism of introduction remained conjectural, but presumably would be similar to that for Amblyomma variegatum. (USDA APHIS VS, San Juan)

Concurrent infestations with the TBT and the tropical cattle tick have provided an interesting opportunity to compare infestation patterns. Tick infestations with TBT have generally resulted in slow and almost hesitant spread from farm to farm and from focus to focus. Over the period reported here, there have been a total of 3 established foci on St. Croix; 3 relatively diffuse foci on Puerto Rico; 1 on Vieques; and 1 on Culebra. In contrast, Boophilus microplus has spread rapidly from an original focus discovered in January 1978 in Utuado, the mountainous and centermost municipality, to cover essentially all herds in all of Puerto Rico's municipalities, including the 2 island municipalities, all by late 1979. (Bokma 1983; Suthern et al 1984; USDA APHIS VS, San Juan)

The eradication effort against the TBT in Puerto Rico and Vieques from 1981 to 1986 eventually involved 188 premises in 10 municipalities. This markedly contrasts with the current eradication effort against Boophilus microplus, now covering approximately 80 per cent of the island's livestock herd and well over half of the island. The Boophilus microplus effort currently covers approximately 50,000 herds of livestock under continual surveillance and livestock movement restrictions. There are approximately 8,500 known infested herds under treatment. The program expects to include the entire island of Puerto Rico within 1 year with at least another 10,000 herds. All of these are assumed infested with Boophilus microplus. (USDA APHIS VS, San Juan)

Surveillance for the TBT in our area has depended on the physical presence and activities of the livestock inspectors, veterinarians, and livestock handlers and owners on farms. On St. Croix, livestock owners, governmental veterinarians, extension and University personnel, and abattoir inspectors have all had important roles in detecting and reporting the TBT. In Puerto Rico, this surveillance has depended markedly on the Tick Program inspectors who see thousands of the preferred hosts in their Boophilus microplus eradication efforts. As the Tick Program increases in coverage of Puerto Rico, so does the level of surveillance.

The risk of spread of TBT apparently has been reduced as evidenced by the relative lack of findings subsequent to the eradication efforts in St. Croix, Puerto Rico, and Vieques. Once established in an area such as the U.S. Virgin Islands or Puerto Rico, the TBT has successfully demonstrated its ability to infest new areas via mechanisms which include the movement of infested livestock and presumably the movement of TBT on free-roaming birds or mammals.

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Table 1. Findings of <u>Amblyomma variegatum</u> on St. Croix

Location (Estate)	First finding	Extent of Focus
Prosperity	Aug 1967	6 farms
?	Aug 1969	1 farm, 1 male TBT
Betty's Hope & Grove Place	Mar 1971	3 farms
River	Nov 1985	1 farm, 1 male TBT
Sion Farm	Jul 1987	3 sites

Table 2. Initial Findings of *Amblyomma variegatum* on Puerto Rico (Main Island)

Location	First finding	Extent of Focus (1981-1985)
Cidra	Apr 1974	76 herds, 13 communities
Cayey	Jun 1974	4 herds, 3 communities
Caguas	? 1976	Not confirmed
Comerio	? 1976	19 herds, 4 communities
Carolina	Jun 1977	Not confirmed
Naguabo	Nov 1977	Not confirmed
Aguas Buenas	Nov 1977	5 herds, 2 communities
Aibonito	Dec 1977	2 herds, 1 community
Vega Alta	Apr 1978	Not confirmed
Coamo	May 1978	Not confirmed
Rincon	Jun 1978	Not confirmed; 2 male TBTs Aug 1988
Aguadilla	Aug 1978	Not confirmed
Barranquitas	Feb 1979	Not confirmed
Caguas	May 1979	Not confirmed
Yabucoa	Oct 1979	Not confirmed
San Lorenzo	Nov 1979	Not confirmed
San German	May 1980	Not confirmed
Rio Piedras	Aug 1980	Not confirmed
Naranjito	Aug 1980	1 herd, 1 community
Cabo Rojo	Aug 1980	30 herds, 3 communities
Ponce	Apr 1981	23 herds, 6 communities
Quebradillas	May 1985	1 male TBT
Lares	May 1988	1 male TBT

Table 3. Spread of *Amblyomma variegatum* in Puerto Rico

Year	Number of Tick Infested Herds	Percent Change
1974	24	
1975	51	31.4 %
1976	67	32.8 %
1977	89	30.3 %
1981-1984	188	

Table 4. Initial Findings of *Amblyomma variegatum* on Vieques and Culebra

Location	First finding	Extent of Focus
Vieques	Oct 1980	24 herds
Culebra	Sep 1985	7 herds

The Probability of the Spread of *Amblyomma variegatum* in the Caribbean

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ABSTRACT

Alderink, F. J. and McCauley, E.H., 1988. The probability of the spread of *Amblyomma variegatum* in the Caribbean. Prev. Vet. Med.

The risk of a disease occurring is often more difficult to estimate than estimating a monetary value of the losses sustained when the disease occurs. The probability of a noninfested island in the Lesser Antilles becoming infested with *A. variegatum* was integrated into the formula for calculating the present value of the benefit of avoiding the costs of infestation by the tick. Based on the history of the spread of *A. variegatum* in the Caribbean, the probability of becoming infested was estimated to be 1 island or island group per year and that the tick needed 5 years to spread over a 15 km area from an initial point of infestation. This rate of spread is slow compared to *Boophilus microplus* which spread over the 160 km long island of Puerto Rico in less than 4 years.

"Frequency of alternative host parasitism of Boophilus microplus in an eradication program", J. Duncan, DVM, San Juan, Puerto Rico.

Veterinary Services is carrying out a cooperative program with the Commonwealth of Puerto Rico to eradicate the Tropical Cattle Tick, Boophilus microplus from the island. The eradication program is based on systematic tick treatment of all potential hosts-cattle, goats, sheep, and horses. Data from surveillance scratches over a 2-year period were analyzed to estimate the frequency with which herds of various potential host species became infested with B. microplus, when only that host species was present on a given premises. Preliminary results indicate that goat herds had an extremely low rate of infestation. The rate of infestation of horse herds was about 20 times greater than that of goat herds, and cattle herds had the highest rate of infestation, about 20 times that of horse herds. These results suggest that goats are infrequent alternative hosts for B. microplus in a field setting where no other alternative or primary host species are present.

Escherichia coli 0157:H7: On the Trail of a Reservoir

Larry D. Shipman, K. D. Greene, J. G. Wells, et al.

Since its recognition as a human pathogen in 1982, *Escherichia coli* 0157:H7 has been shown to be an important cause of hemorrhagic colitis, hemolytic uremic syndrome, and thrombotic thrombocytopenic purpura. The first reported laboratory evidence of an animal reservoir was obtained in 1986, when the organism was isolated from dairy cattle in Wisconsin. To define this reservoir further, we surveyed dairy farms in Washington State and Wisconsin dairy farms that had been studied a year earlier for *E. coli* 0157:H7 infection. In Washington, four of eight herds surveyed yielded *E. coli* 0157:H7; six of 524 animals sampled were infected, including both males and females; infected animals were more likely to be < 12 months of age. Carriage lasted at least 37 days, and two different strains were identified by plasmid profiles. In Wisconsin, we detected *E. coli* 0157:H7 on one of three farms at which positive results had been obtained a year earlier. Herd infection was not accompanied by animal illness, and current stool-culture techniques showed that animal infection rates in positive herds were low. Multiple strains occurred in one area and even in a single herd. We are evaluating cattle with false-positive serum agglutination reactions for *Brucella abortus* that reportedly can occur after *E. coli* 0157:H7 infection. If this cross-reaction also occurs in the field, national *Brucella* surveillance, currently conducted by state and Federal agricultural agencies, may provide a relatively simple means of identifying infected animals and may ultimately provide a basis for controlling human *E. coli* 0157:H7 infections.

PREVENTIVE VETERINARY MEDICAL ASPECTS OF INTERNATIONAL GERM PLASM EXCHANGE

John A. Acree, DVM, MPVM

In regulating any international germ plasm movement, we must be as responsible as we are responsive. To do this we must know, in relation to each such movement:

1. who our clients are

2. what disease agents we should consider

3. where the benefits from the importation will accrue

4. how much risk of disease agent importation we should expect and

5. how much risk we, as responsible officials, can accept.

We must then develop a strategy that will keep the expected risk within the acceptable risk.

Client Identification:

As regulatory officials, we have our first responsibility to the public we serve. Our next responsibility, in this case, is to the international animal health community. We are then, of course, responsible to <u>all</u> owners of the livestock that make up our national herds and flocks. We must keep this client order clearly in mind as we develop schemes for the sanitary movement of animal germ plasm from nation to nation.

Agent Identification:

For each country of origin of a proposed germ plasm importation, we must list the disease agents that might accompany such germ plasm. We should then identify which of these agents are not present in the country of destination but could spread or become established there. These are the "agents of concern" and can be ranked according to the magnitude of the damage they could inflict on the national herd or flock of the destination country.

Benefit and Risk Identification:

We assume there will be benefits from a germ plasm importation, and we know such benefits will accrue to only two groups. First, there are the entrepreneurial rewards, usually immediate and substantial, to the importers, promoters and initial distributors of the germ plasm. Second, there are the benefits, usually realized only after years or decades, to the consuming public of the additional production provided by this germ plasm <u>that is over and above the increase expected from the similar use of domestic genetic resources</u>.

We know that we can never transport germ plasm without the risk of concurrently transporting an exotic disease. We also know that this risk is shared, but not equally shared, by three groups. The first group is the general public in the country that receives the germ plasm. They will bear the cost of containing and eradicating any exotic disease that is introduced. The second group is made up of the entrepreneurs who promote the importation. They stand to lose, at most, their investment in this enterprise. The third group is made up of the owners of the animals infected with, or affected by, the exotic disease. It is the members of this last group who will suffer the greatest individual losses.

Obviously, there is inequity in the distribution of risks and benefits associated with the importation of exotic germ plasm. Very few livestock owners will realize any of the entrepreneurial benefits from the importation of novel genes. They may even be owners of competing breeds or species. However, all livestock owners are vulnerable to substantial losses if a serious disease gains entry via such an importation. We are therefore bound to recognize a very special responsibility to these individuals, and do all in our power to reduce the probability of a disease agent's introduction to an acceptable level.

Acceptable Risk Determination:

How then, do we determine what the maximum acceptable probability of an exotic disease agent's introduction should be? To be responsible to our clients we should first obtain the assurance of experts in the field that the infusion of this exotic germ plasm into our national herds or flocks will increase their productivity substantially above that which we would expect from the proper exploitation of our domestic gene pool. Or, we need to be convinced that importation is the only method of preserving the genetic diversity of a certain species. If these promised benefits from the importation do not exist, then a valid justification for incurring any risk of introducing an exotic disease does not exist. However, we must keep in mind that, if we make no provision for the legal acquisition of genetic material when there exists a popular perception of its value, it will be entered in an illegal manner. As smuggling generates an enormous risk of introducing exotic disease agents, reducing its likelihood may often be the sole, but sufficient, justification for a germ plasm importation.

Once the importation is justified by one or more of the above reasons we must develop an equation, on an agent by agent basis, that will estimate its acceptable order of risk. This equation may be derived from the benefit/cost risk (B/CR) ratio equation which is presented as follows:

Where,

ni = The expected number of import units (breeding animals, embryos, insemination doses, etc.) needed to accomplish the purpose of the germ plasm exchange.

ns = The expected number of import units that may be smuggled into the country if no practical, legitimate method is provided.

pDI = The probability that one import unit will introduce the disease agent in question into the national herd or flock of the destination country so that the agent spreads, becomes established, and causes disease.

qDI = (1-pDI), or the probability that one import unit will not introduce the disease agent.

pDS = The probability that one smuggled unit will introduce the disease agent in question into the national herd or flock of the destination country so that the agent spreads, becomes established, and causes disease.

qDS = (1-pDS), or the probability that one smuggled unit will not introduce the disease agent.

YB = Yield benefit, or the estimated increase in production, resulting from the importation of ni units of this germ plasm, above the increase that would be expected from the proper exploitation of domestic genetic resources within a like period.

PB = An estimated benefit reflecting the value of importing ni units of this germ plasm in order to preserve a genetic diversity.

DC = The estimated total cost, public and private, that results from the introduction, spread, and establishment of the agent in question and the disease it causes.

B/CR = The ratio of the estimated benefit to the estimated risk of cost from the importation. Is usually set empirically.

Then,

$$B/CR = \{YB + PB + [DC \times (1 - qDS^{ns})]\} / [DC \times (1 - qDI^{ni})]$$

A B/CR ratio of less than one indicates a seriously flawed regulatory strategy. A value less than 10 does not reflect proper consideration of all those who stand to lose but have no stake in any gain from the importation. Because a substantial portion of the benefits may only be realized after decades, while substantial losses could accrue within a few months, the ratio should be closer to 50. In many cases this value should be doubled to compensate for the uncertainties in the estimates. Therefore a B/CR ratio of 100 might be the minimum used in the calculation of most pDI's.

Once the B/CR ratio is set as a constant (K), the maximum "probability of disease introduction per import unit" (pDI), which is the real value of concern, can found by solving for it in the above equation as follows:

Where,

$$K = \{YB + PB + [DC \times (1 - qDS^{ns})]\} / [DC \times (1 - qDI^{ni})]$$

Then,

$$qDI^{ni} = 1 - \{YB + PB + [DC \times (1 - qDS^{ns})]\} / (DC \times K)$$

And,

$$qDI = (\text{above right-hand quantity})^{1/ni}$$

Therefore,

$$pDI = 1 - (\text{above right-hand quantity})$$

The precision of this probability is, of course, no greater than the accuracy of the many estimates that enter into the equation. However, its value indicates the relative order of probability that we must require if we are to responsibly regulate the international movement of germ plasm. In a hypothetical example where,

B/CR = K = 100

ni = 10,000

ns = 100

pDS = 0.0001

YB = $35,000,000

PB = $10,000,000

DC = $500,000,000

The pDI would be 0.0000001

Strategy Development:

Once we have a good estimate of the maximum "probability of introduction per import unit" for each disease "agent of concern," we can develop an import scheme. This scheme, of course, must insure that no import unit will exceed the maximum probability for any agent.

We must, therefore, make two very critical assumptions. The first is that import units meeting this requirement, that is

units that do not exceed the maximum probability of introduction for any agent of concern, do exist in the country of origin. The next is that the import units in the country of origin that do meet these requirements are the genetic equivalents of those that do not. Circumstances in which both of these assumptions cannot be made will be very rare.

The basic plan, then, is to identify and isolate the acceptable import units by the stepwise application of preventive medical tools. In an oversimplified extension of the above example, we might qualify animals for importation from a country by first requiring certification from animal health authorities that the import units are from a subpopulation that has no record of exposure to a particular agent for a certain period. Let us say that experience with such certifications has made us confident that fewer than 1 in 100 of the younger animals will actually have been exposed ($p = 0.01$). We may combine this with a serologic test that has a false negative rate for certified animals of less than 1 in 1000 (combined $p = 0.00001$). Another step would be to subject all those negative to this test to an agent isolation test with a false negative rate for certified animals that are seronegative of 1 in 10 (combined $p = 0.000001$). By requiring a quarantine of several incubation periods in length, followed by another series of tests, we might hope to disclose 90 percent of any remaining false negatives for a final combined probability of 0.0000001. In this way we would be able to identify and isolate those import units that have an acceptably low probability (1 in 10,000,000) of introducing the disease agent.

It is with schemes such as the above that we have successfully honored our responsibility to our clients while responding to the demands for exotic germ plasm.

As technology has advanced we have added tools, we have not changed the proven approach. When it became possible to freeze bovine semen we used that medium of germ plasm importation as a tool so that the certification and testing of a few donors can basically qualify thousands of germ plasm units for importation. In addition, by using this medium we can sacrifice as little as 10 percent of the importation cohort (i.e. a collection of raw semen) to an agent isolation test because a tenth of a well mixed collection of semen is very representative of the other nine tenths. In other words, let us assume that the disease agent is associated with the sperm and that there is an average concentration of 1 billion sperm per ml. in an average ejaculate of 8 ml. Therefore, the failure to isolate a disease agent from 800 million randomly selected individuals out of a population of 8 billion would provide 95 percent confidence that the sperm infection rate would have to be 3.7 or less per billion. If the agent is suspended in the fluid portion of the semen then the failure to isolate from the 10 percent sample provides 95 percent confidence that total collection contains less than 5 detectable units. The usual extension of semen reduces even more the possibility of an agent, undetected in the 10 percent sample,

being transmitted at or above an infective dose. We can also quarantine, at very little cost, the straws or ampoules of semen in liquid nitrogen until several normal incubation periods of the disease have passed, so that we may verify the freedom of the donor from exposure to the disease agents of concern.[1]

I hope that we can all see the use of the frozen embryo as a similar tool. It is, after all, only another method of lowering the risk of germ plasm importation and not a new form of germ plasm. The certification and testing of a few donors can still qualify a number of germ plasm units for importation. Because the failure to isolate an agent from one embryo, selected at random from a collection of ten, can be expected to occur once in every four attempts even when 50 percent of the embryos are contaminated, we cannot use one of the most useful tools we had with semen. However, we can hold the embryos frozen for very little cost while we retest their donors for evidence of exposure to the disease agents. The concentration of any agent suspended in the fluids surrounding the embryo at time of collection will be diluted almost 1000 times by the flushing process alone and we have the option of increasing this dilution by passing the embryo through a series of "wash" solutions.[2] For a number of physiological and anatomical reasons the embryo is less likely to be contaminated with a disease agent than semen or a breeding animal.[3] Once the proper research has been performed the embryo may permit us to be, at once, responsive and responsible to all of our clients.

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OCCURRENCE OF DRUG RESIDUES IN MEAT AND MILK: IS THERE A TECHNICAL SOLUTION?

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INTRODUCTION

The term "technical solution" was popularized by Garrett Hardin (1) more than 20 years ago in discussing many dilemmas facing modern society, those dilemmas not solvable by science and technology alone. Though residues in meat and milk are not on the same scale of horror as nuclear war, world-wide famine and population problems, I would like to suggest that the occurrence of drug residues in meat and milk are problems also not amenable to technical solution alone.

FDA, EPA and our sister agency in USDA, FSIS, struggle daily with the problems of residue detection and programs for residue avoidance. Their approaches do include both technical and non-technical ones, including education in the latter category. This paper considers some of the literature on farmer behavior and attitudes which may help develop and target educational programs to be more efficient in fostering residue avoidance. Several studies will be briefly described for methodologies and conclusions and commentary on how this information can be used to better target educational programs.

STUDY A

In Study A (2), dairy farmers who had incurred one or more milk residue violations between 1980 and 1984 (designated R in this text; random sample of 1200) and a matched group of farmers who had not committed any such violations in this same time period (designated C; random sample of 1800) were asked to fill out a questionnaire regarding (1) management and disease in their herd, (2) their attitudes toward and (3) knowledge-seeking behavior regarding residues.

Conclusions from Study A were briefly as follows:
(1) Management and disease. (a) Increased herd size leads to increased violations. (b) Increased number of farm employees leads to increased violations. (c) Mastitis/metritis was found in 26% of the R cows as compared to 20.5% of the C cows. (d) Increased use of medicated feeds leads to increased residues. (Pre-medicated feeds were more at fault; we had predicted that feeds medicated on the farm would be associated with increased residues because of mistakes in mixing antibiotics. However, in this study it seems that farmers using pre-medicated feeds may be less aware of the withdrawal times for the medicated feed).

(2) R farmers were more likely to have insufficient knowledge about the withdrawal period (didn't read feed label?) for the medicated feed while C farmers were more likely to have had errors due to hired help.
(3) Occurrence of residues was reduced in herds owned by farmers who thought residues are a major public health problem (though 90% of both groups reported to consider adhering to recommended withdrawal times very important). However, 75% considered that public health was less important than economic factors. In an open comment section farmers asked for more information on withdrawal periods (R = 24%; C = 11%) and on public health (R = 38; C = 17%).

In ranking of people to contact about residues and drug withdrawal times, veterinarians were the preferred source (45%) compared to the feed supplier (18%), farm magazine (15%). Interestingly the extension specialists so often thought in the past to be an important source of information did not rank high here: cooperative extension, 13%; university extension, 6%. Neighbors were a distant 3%. Furthermore 94% of all farmers ranked veterinarians the highest of all for giving useful information on residues.

Understanding gained from this study suggests that targeted education programs might work for dairy farmers with residue problems. First the program must be available to farmers and their helpers, especially part-time employees. Second, there should be some emphasis on attitude change as regarding public health implications of residues. Third veterinarians should be incorporated into this process since they have the respect of the farmers as reliable and useful sources of information. Not all dairy farmers use veterinarians (3) and since many who do use veterinarians, do not do so with sufficient frequency to make such advice readily available, it would seem that public practice veterinarians could be very useful in filling needs for education and attitude change. Not to be ignored is a role for economic incentive to avoid residues.

STUDY B

This study (3) tracked potential residues in the meat of culled dairy cows based on FAHRMX records from all Michigan dairy farms included on this database. The records of disease, drugs administered, production, etc., are added to the database in a way that a farmer cannot change the information once it is logged in. Therefore if a farmer administers an antibiotic one day and decides to sell to slaughter the next day, all information remains intact. Twenty-three Michigan dairy herds were enrolled in FAHRMX between January 1981-1985, forming the base for determining cattle sold to slaughter before the end of the drug withholding time. FAHRMX farmers tend to be interested in new management techniques, keep good records and probably have better than average management skills.

Cows culled too soon were most likely to have mastitis or metritis (p > .01); other dairy production-related diseases such as retained placenta, displaced abomasum, and milk fever were also more likely to be culled too early (p > .05). Drugs very commonly used during this time frame to treat mastitis (oxytetracycline, gentamicin, and chloramphenicol) accounted for 57% of the violations. Compliance was high for individual cows (97%) giving a 3% rate for potential violations due to early culling.

Increasing voluntary compliance has been a goal of USDA/FSIS and FDA. If so, this study suggests that a targeting of education tc dairy farmers and their employees regarding the most commonly used drugs for the most common disorders (mastitis, metritis).

CONCLUSIONS

These studies and others suggest that part of a non-technical solution to drug residue problems will involve both education and attitude changes. In terms of education, the education must be appropriate information related to the most commonly abused antibiotics, particularly that related to the most common diseases and medicated feed use. This information must be targeted to individuals, both farmers and family members and particularly part-time helpers. The information must be provided by trusted, knowledgeable, non-biased sources, studies showing that veterinarian was the person of choice. Information to change attitudes regarding public health aspects of drug residues should be encouraged. Some role for economic incentives must not be overlooked.

COMMENTARY

1. Where private practice veterinarians are used in food-producing animal therapy, there is probably adequate instruction on withdrawal time. But many studies indicate that fewer and fewer farmers use the services of a private practice veterinarian.

2. Many residue problems appear to be related to use of premedicated feeds which do not require a veterinarian to prescribe, thus there may not be a veterinarian directly involved as an advisor.

3. Number 1 and 2 above suggest a role for public practice veterinarians in educating dairy farmers (and others) about residues, and in helping change their attitudes toward public health implications of drug residues.

4. There should be careful epidemiological traceback of all drug residue violations, associated with education regarding their use at the time of the traceback. For now these tracebacks are

handled through FDA. However, FDA's investigators are not veterinarians nor are they specially trained in epidemiological investigations. Since USDA/APHIS/VS veterinarians have on-farm authority for disease tracebacks, it seems reasonable that residue traceback responsibilities be moved from FDA to VS, or at least contracted out to VS. It would be imminently reasonable that our APHIS/VS field force be included in an educational network in sharing knowledge about drug residues with farmers and the general farm community.

I believe that residue occurrence is a problem that requires more than a technical solution. I hope that APHIS/VS will be allowed to contribute to the goal of residue avoidance in the future.

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TENNESSEE NAHMS, ROUND TWO: PRELIMINARY DATA ON THE OCCURRENCE AND COST OF DISEASE IN 60 BEEF COW/CALF HERDS

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ACKNOWLEDGEMENT

I would like to acknowledge the work of Dr. John New, who is an Associate Professor in the Department of Environmental Practice, at the University of Tennessee's College of Veterinary Medicine. Dr. New has been coordinating the activities of the National Animal Health Monitoring System in Tennessee since its implementation in 1983. My presentation is based on data that Dr. New has compiled during the current round of data collection in Tennessee, Round 2.

INTRODUCTION

This report will discuss preliminary data on the occurrence and cost of disease in sixty beef cow/calf herds in Tennessee. This data is preliminary because the collection of information in this round will not be completed until December. This presentation will incorporate only information collected up through April of 1988, and represents from 5 to 9 months of data for any given study herd, because enrollment of the 60 herds was staggered over several months beginning in June of 1987.

First, a brief description of the 60 herds: The median herd size is 54 head based on the cow/calf inventory. The average is 83 head, with a range of 8 to 690 head. These 60 NAHMS were selected for one of three strata so as to correspond to the distribution of cattle in Tennessee beef herds by herd size. Stratum one contains 29 herds having from 8-49 head, and represents 48% of all Tennessee beef cattle. Stratum 2 contains 13 herds having from 50-99 head and represents 24% of all cattle. Stratum three includes herds with 100 or more head and represents 27% of all beef cattle in Tennessee.

OCCURRENCE AND COST OF DISEASE

In examining these 60 herds, what health problems were encountered and with what frequency? Although I can not present actual incidence data in this preliminary report, I can show the percentage of the 60 herds that experienced economic loss in 8 different body system categories. (Figure 1).

Fifty-seven percent, that is 34 of the 60 herds, experienced loss in the Reproductive category, making it the most frequently

reported. The reproductive disorder experienced most often by these NAHMS herds was dystocia. The category reported by 45% of the 60 herds is one that is referred to as Sudden Death. This category is used in reporting animals dying suddenly due to disease or trauma. For the majority of deaths in this category, the cause was not determined. Disorders of the enteric system occurred often enough to make this category the third most frequently reported. Diarrheas of unknown cause were the largest contributor to this category with intestinal parasitism next. Disorders of the respiratory tract and infectious disease round out the top five with 25% of herds reporting problems in both these categories. Respiratory infections of calves were the most commonly experienced loss in the respiratory group. While in the Infectious category pinkeye was the primary problem. Less frequently reported categories were Nutrition and Growth, here abbreviated NG. Musculoskeletal disorders abbreviated MS and Malnutrition abbreviated MN. Grass tetany was the most frequent contributor to the Nutrition and Growth category and foot rot comprised most of the musculoskeletal disease. The Malnutrition category is used to report generalized diseases and conditions that result in body wasting, and that also do not fit easily into any other category. Seventeen percent of the herds reported that they had not suffered any health related problems.

Figure 1 also lists actual dollar amount lost by producers in each category, ranging from a high of over $25,000 for reproductive disease to a low of approximately $1600 for Musculoskeletal disorders. However the dollar figures due not accurately represent the economic impact of disease, because the number of animals affected varies greatly in each category. Calculating cost per head, based on the average cow/calf inventory, gives a better indication of the loss experienced in each category.

Figure 2 shows the loss suffered by the 60 herds on a per head basis. Included in the cost per head figure are veterinarian's fees, drugs, labor, and animal losses. The average cost per head lost to all disease categories, for all herds is $12.62. The Reproductive category here abbreviated RP, is not only the most frequently reported category, but is also the most costly on a per head basis at $6.20 and makes up 49% of the total. Sudden Death, abbreviated SD, always extremely costly on a per case basis accounts for 21% of the total, at $2.65 per head. Nutrition and Growth, although only the sixth most frequently reported category, is the third most costly at $1.08 per head. The remaining five categories combined account for only 24% of the total cost per head.

How does this cost per head loss break down based on herd size? The cost per head for all disease categories was determined for the three strata. Small (8-49 head) and medium size (50-99 head) herds incurred per head losses at a higher level than the 60 herd average at $13.40 and $13.59 respectively. Larger herds (≥ 100

head) at $10.67 did not suffer as great a loss on a per head basis.

Now that we have looked at the cost of disease, lets consider the cost of preventing it. Figure 3 shows the percent of herds that reported practicing preventive acts in each of the body system categories. The preventive acts practiced by the most producers with 60% of the herds reporting their use, are those in the Enteric category. Drugs used to control internal parasites are essentially the only preventive acts reported in his category. Forty-eight percent of the study herds reported preventive acts in the Dermatologic category. Prevention of dermatologic disease is entirely due to the control of external parasites such as lice, warbles and flies. Preventive acts aimed at reducing loss in the sudden death category are primarily blackleg vaccinations. Fourth among herds reporting preventive acts is the Reproductive category. Vaccination for leptospirosis is the most commonly used prevention in this category. A Miscellaneous category, here abbreviated MISC, rounds out the top five. Multivalent vaccines make up the bulk of acts reported in this category. The remaining four preventive categories are Respiratory, here abbreviated RS, Infectious abbreviated IN, Nutrition and Growth and Malnutrition. The administration of vaccines is the common preventive act in the Respiratory and Infectious categories. The primary Nutrition and Growth category preventive act is the supplementation of magnesium to prevent grass tetany. Prevention in the Malnutrition category is mainly the use of protein supplements. Thirteen percent of the herds reported that they did not practice any preventive procedures.

What about the cost per head for preventive acts? Figure 4 shows that the total average cost per head spent by the 60 herds on preventive acts is $3.82. The category in which the largest amount of money was expended on a cost per head basis is the Enteric category, which at $1.48 accounted for 39% of the total. The Dermatologic category was the second most costly at $0.66, and accounts for 17% of the total . Together the control of internal and external parasites in these two categories accounts for 56% of the total cost per head. The third most costly preventive category, which was only the 7th most frequently reported, is the Infectious category and accounts for 15% of the total. The remaining 6 categories combined make up only 29% of the total cost per head spent on prevention.

Do producers with different size herds spend more or less than the average of $3.82 per head? When we look at cost per head for preventive acts by herd size we find that small herds at $2.86 spend less, while medium size herds at $5.21 and larger herds at $4.35 expend more per head than the average.

If these costs, that is the cost per head due to disease loss and the cost per head spent on prevention are combined, we get the

following picture, (Figure 5). The total average cost per head for all categories, including loss and preventive acts, for all herds is $16.44. The Reproductive category accounts for 40% of his total at $6.51. The Sudden Death category accounts for 18% of the animal health related cost per head at $2.91. The Enteric category is the third most costly accounting for 14% of the total at $2.35. This category is the only one in which the amount spent on prevention was greater than the amount lost due to disease. The remaining seven categories account for only 30% of the combined total cost per head disease loss and prevention.

LOSS DUE TO REPRODUCTIVE DISEASE

You will recall (Figure 2) that the Reproductive category accounted for roughly half of the loss experienced by Tennessee beef cow/calf producers. In the final analysis of the complete NAHMS data set this category will be very thoroughly examined to determine possible causative factors and intervention strategies. In a less rigorous manner I looked at this category to see if I could note any factors that may account for the high loss due to reproductive disease.

First, this category was broken down by herd size. Small herds suffered over twice the loss on a cost per head basis at $8.85 than did the medium size and larger herds, at $3.88 and $3.60 respectively. Previously I had mentioned that dystocia was the most frequently reported problem in the Reproductive category. Dystocia is a reproductive disease that can result in mortality in the calf, the dam or both. Could the small herds greater loss be due to a greater frequency of mortality in the calf or the dam, as an outcome to reproductive events?

How often did a disorder in the Reproductive category result in the loss of a full term calf? Small and medium size herds both experienced a 16% calf mortality, while larger herds experienced a 19% mortality. This data suggests that herd size does not seem to be a factor in whether or not the calf survives a reproductive disorder that afflicts its dam.

How often did a disorder in the Reproductive category result in the loss of the cow? This table gives the percentage of reproductive events whose outcome is mortality in the dam. Small herds suffered a 35% dam mortality, while medium size and larger herds experienced a 4% and 12% mortality respectively. The loss of a breeding age beef cow is a very costly event and could result in the small herds greater cost per head in the reproductive disease category. I do not mean to suggest that other factors are not at work here and all available information will be applied to this problem in the final analysis. However I offer this as brief example of the sort of query-answer pathway that can be pursued with the NAHMS data base.

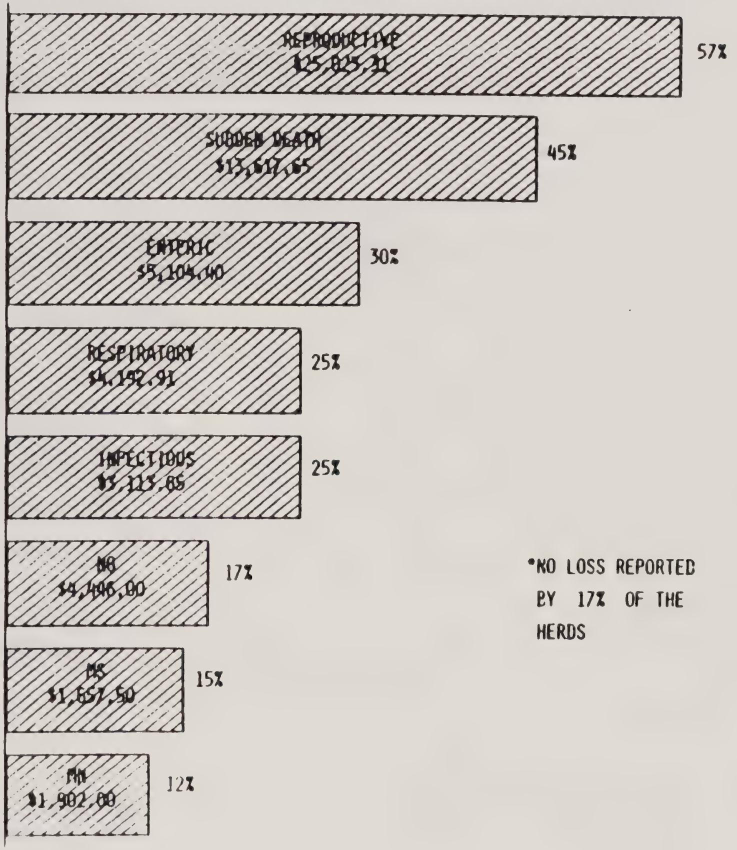
SUMMARY

In summary this partial data set has shown that Tennessee Beef cow/calf producers are averaging $16.44 per head for health related events in their herds. Of this total 78% represents the cost of disease occurrence in their herds. The remaining 22% is the money and labor that producers expended in the hope of preventing loss due to disease. The Reproductive category is the most costly disease condition occurring in these herds and is responsible for 49% of the total cost per head lost due to disease of $12.62. Control of internal and external parasites accounts for 56% of the total cost per head spent on prevention of $3.82.

I would like to remind you that these are preliminary results and for this reason may contain bias. A seasonal bias is present because herds were enrolled in mid to late summer and this data set only includes information collected through April. Diseases of late spring and early summer will be under represented, and the data does not cover a complete calving season. There may be a herd size bias as well; for example if smaller herds were signed up early on in the enrollment period their problems would be over represented, because there would be more months of data collections from them than there would be from larger herds enrolled later on. This report does indicate trends such as the high loss due to diseases of reproduction, and the heavy reliance parasite control as a preventive practice. Such strong trends are unlikely to be overturned in the final data set. Thorough analysis of the complete data set will provide detailed examination of health events in each category and will either explain why losses occurred or will provide enough information to formulate hypothesis and conduct further investigations.

FIGURE 1

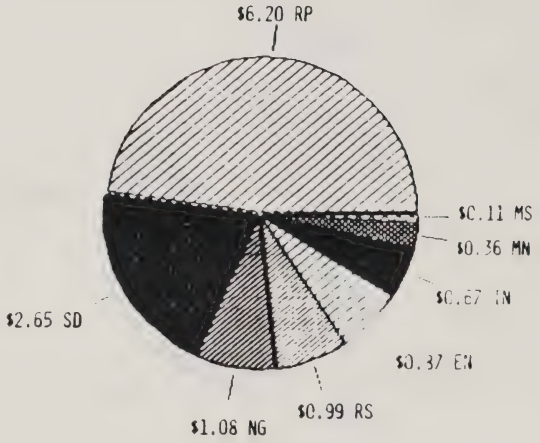
DISEASES/CONDITIONS REPORTED



*NO LOSS REPORTED BY 17% OF THE HERDS

FIGURE 2

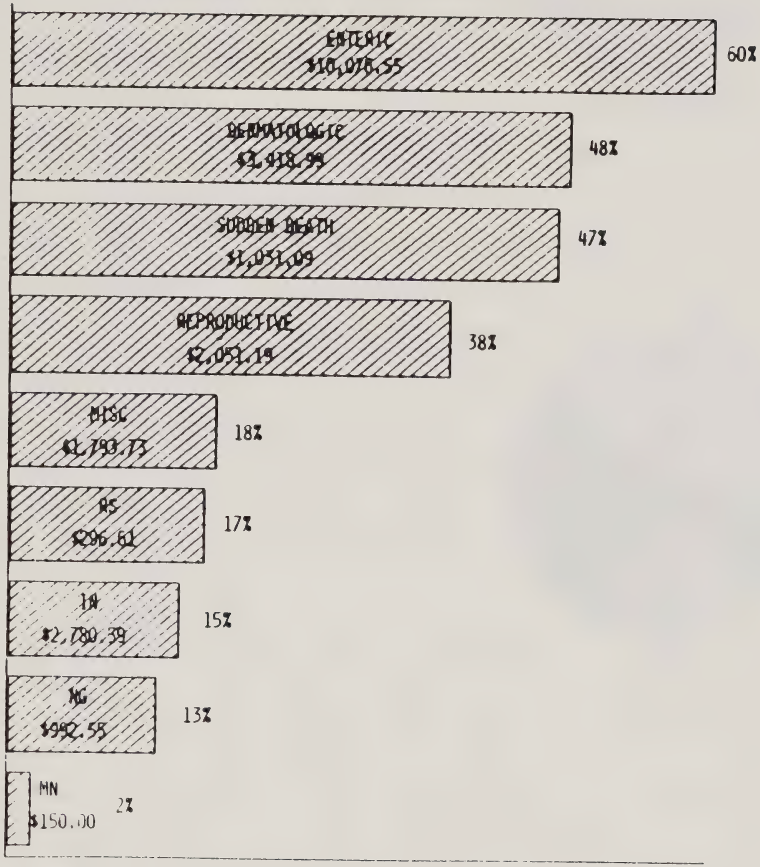
COST PER HEAD
DISEASES/CONDITIONS



TOTAL $12.82

FIGURE 3

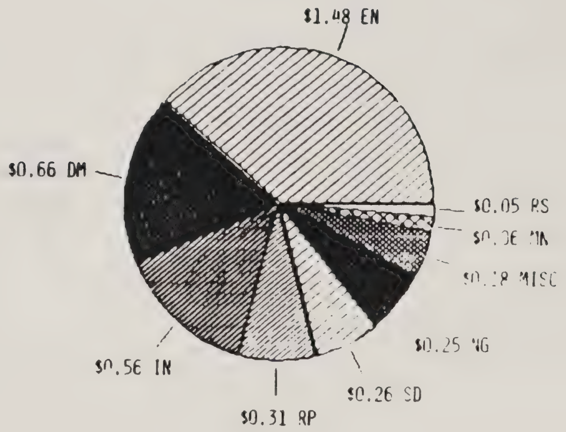
PREVENTIVE ACTS REPORTED



*NO PREVENTIVE ACTS REPORTED BY 13% OF HERDS

FIGURE 4

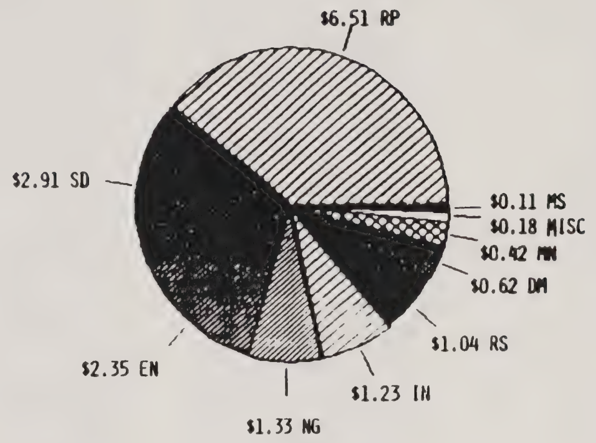
COST PER HEAD PREVENTIVE ACTS



TOTAL 3.82

FIGURE 5

COST PER HEAD
TOTAL



ALL HERDS/ALL CONDITIONS = $16.44

The Significance of Biovar in the Epidemiology of Bovine Brucellosis in Puerto Rico: Description of Outbreak and Tracing Activities

Bob H. Bokma, DVM, MPVM, Diplomate ACVPM

A 1988 outbreak in Puerto Rico of Brucella abortus biovar 2 in beef cattle is described. The significance of the relationship of biovar to the epidemiology of infection is explored. Previous brucellosis infections for at least the previous 7 years through 1985 were biovar 1, with only 2 exceptions, and involved predominately dairy herds. Puerto Rico was granted Class Free status in October 1986, 18 months after the last previously known infected animal was sacrificed in April 1985. Previous biovar 2 reports from Puerto Rico were during the period December 1982 through February 1983 from a dairy cattle herd with no known relation to the current outbreak and in May 1983 from a beef herd which may be related. Registered beef cattle, which were imported from Texas during the period 1974 to 1981, are another possible source of the outbreak.

Introduction:

The Brucellosis Eradication Program in the United States is a cooperative program involving the departments of agriculture of individual states and the USDA Animal and Plant Health Inspection Service. The program has been very successful at reducing levels of bovine brucellosis across the country, as well as eliminating herd infections. Many states are now considered free of infection. (USDA Animal and Plant Health Inspection Service (APHIS)) A classical description of the disease as it has presented in various species, the worldwide distribution, the laboratory diagnosis, and the epizootiology and control is found in Spink (1956). Acha and Szyfres (1987) update this information.

In the Commonwealth of Puerto Rico, the Brucellosis Program stresses quarterly milk ring tests at dairies, slaughter animal identification and testing, and testing on entry and again after 60 days of cattle brought into Puerto Rico, usually from the U.S. mainland. In addition, any animals found suspicious for brucellosis on any blood test are identified and the vaccination status determined. These animals are carefully monitored by serology and culture, both of udder secretions and of tissues, if the animal is sacrificed. Swine are also covered and Puerto Rico is classed as "Validated-Free" of swine brucellosis.

The Commonwealth of Puerto Rico has been classed "Free" of bovine brucellosis since October 1986. However, commencing in March 1988, 3 new cases of bovine brucellosis, 2 of which were culture positive and typed as biovar 2, were discovered in beef cattle. The estimated number of all cattle herds and of dairy herds in Puerto Rico is 36,000 and 514, respectively. Currently, the overall herd infection rate is 0.01 %.

Tracing and establishing sources of infection for outbreaks are useful in determining the priorities for the various epidemiological surveillance methods. They may also allow the epidemiologist to link specific cases of brucellosis, which can be of importance in litigation cases or in demonstrating effectiveness of a state's surveillance program. Microbiological characteristics of the disease agent, such as the serotype or biovar, can provide a useful marker or epidemiological tool in determining identity or relatedness of agents in different cases.

The purpose of this paper will be to describe the current outbreak investigation and discuss the value that biovar type has had in determining the probable origin of the infection.

Outbreak Description (Figure 1):

On March 21, 1988, the serology section of the Dorado Commonwealth/Federal Veterinary Diagnostic Laboratory reported 3 rivanol-test-positive samples from a slaughter plant. The animals represented by these samples were classified as reactors and were identified on test charts as female cattle belonging to Angel Riquelme of Aguadilla. The animals had been slaughtered on March 15 at the Arecibo abattoir, located in northwestern Puerto Rico, and carried identification consisting of backtags and eartags.

Traceback activities verified the herd of origin. Six pastures in the northwestern municipality of Aguadilla and an additional pasture located in the southwestern municipality of Cabo Rojo, apparently vacant at the time, were identified and quarantined.

On April 6, 1 of the pastures tested had 21 head (16 red or white Brahman cows and heifers, 1 red Brahman bull, and 4 calves). There were 2 rivanol-200-positive reactors, both adult red Brahman cows, called on the herd test. These samples were positive at 1:40 on the complement fixation test. On the serial dilution milk ring test, 1 of these reactors was positive at 1:1024 in 3 quarters. Reactors were killed and tissues collected for culture on April 11. Culture results were negative.

Despite reluctance by the herd owner to disclose his business dealings, the investigative work conducted determined that Riquelme had routinely purchased beef cattle, usually from southern Puerto Rico cattlemen, for fattening and slaughter. All of his premises were under jurisdiction of the Puerto Rico's eradication program for the tropical cattle tick and he frequently required movement passes for additions to his pastures, movements from one premises to another, and from his farms to slaughter. Riquelme also sold animals to other dealers or herd owners via private treaty and occasionally at a local livestock market.

The reactor slaughter animals carried eartags which traced to a tick program quarantine line station and had been issued in early March. Several similar eartag series identified as belonging to Riquelme were issued at approximately that time by the Tick Program.

Riquelme acknowledged buying out a 270-head herd of Charolais, Brahman, and crossbred cattle on a herd dispersal in the southern municipality of Juana Diaz in early March 1988. This herd was identified as being the herd of origin for this infection and belonged to Enrique Ubarri. While Riquelme moved the majority of the animals to his farms, he further dispersed the herd to others in the Juana Diaz area, as well as in western Puerto Rico.

Mr. Riquelme admitted sales of at least 100 Ubarri animals to 16 individuals. No evidence of infection was found during the initial 2 rounds of testing of these herds.

Tracing beyond the Ubarri herd led the investigation to one of Ubarri's source herds, Juan Rivera of Caguas, located in eastern Puerto Rico. At least the 2 on-the-farm reactors at Riquelme's farm had originated from the Rivera herd. This herd consisted of both local cattle and registered Brahman and Charolais cattle brought in from Texas by Rivera and a trading partner, Ruben Rivera, during the 1970's and early 1980's.

The Juan Rivera herd was dispersed in 1985 to Ubarri and to Agripino Lopez, located at 1 of Rivera's original locations and 2 other Caguas locations. Lopez in turn had recently sold replacement beef animals to Domingo Sadurni, located in the southern municipality of Salinas. Tests of the Lopez and Sadurni herds disclosed additional infection. This infection was cultured and proved to be biovar 2.

While both the Ubarri and Rivera herds were dispersed, available records and interviews of herd owners permitted partial reconstruction of the rather extensive cattle movements. Tracing activities have determined that at least 45 herds located in 19 municipalities, including the island municipality of Vieques, were directly exposed to animals which originated from the Riquelme, Ubarri, Rivera, or Lopez herds. Only 3 herds tested to date were determined to be infected. Testing conducted of exposed and adjacent herds has included over 5000 cattle in approximately 105 herds in 21 municipalities.

Discussion:

A distinguishing factor allowing laboratory characterization of biovar 2 from biovar 1 is the lack of growth on various inhibitors, including the dye fuchsin, very low dilutions of the dye thionin blue, and the antibiotic penicillin. Also, biovar 2 hydrolyses urea more rapidly. Microbiology texts describe these distinguishing characteristics and the pathogenesis of infection in detail. (Koneman et al 1983; Joklik et al 1984) While changes between rough and smooth forms or in virulence of one particular strain have been described, evidence for change in biovar type from biovar 1 to biovar 2 is apparently lacking. (Joklik et al 1984)

Characterizations of the relative prevalence in different countries of the different biovars have been published. These are reviewed in a National Research Council (1977) report. The distribution of different *Brucella abortus* biovars has been used successfully to trace infections from herd to herd in several locations. (Acha and Szyfres, 1987; J Huber, pers. comm. 1988) Biovar as a tool in epidemiological tracing would be particularly

useful when culture results are available for all infected herds which may be related to the outbreak in question.

Puerto Rico was granted "Class Free" in 1986 after intensive efforts to eliminate bovine brucellosis. The elimination of the last known focus of infection in March 1985 culminated a successful program. This program consisted of intensive efforts of surveillance for infection; quarantine and testing of infected herds; culture of udder secretions, milk, and tissues and biovar determination of isolates; tracing and testing of exposed animals; testing of adjacent herds; and Strain 19 vaccination, which was implemented in 1977 after several years of prohibition.

Brucellosis eradication efforts were concentrated in dairy herds (well over 90 %), especially in the Arecibo-Camuy-Hatillo milkshed area. During the years of intensive eradication activities, some non-dairy brucellosis cases were encountered. These involved both backyard Holstein beef herds and Brahman, Charolais or crossbred herds. With only 2 exceptions of biovar 2, all previous culture-positive cases of brucellosis were typed as biovar 1.

In Fiscal Year (FY) 1974, there were 2,440 animals called as reactors. The cumulative number of herds under quarantine was at 157 herds, of which 87 had not been infected the previous FY. The herd infection rate was calculated at approximately 0.44 per cent. This compares with the present 0.01 per cent herd infection rate. (Table 1)

The recommendation has been made that Puerto Rico lose its "Class Free" status. This has certainly disappointed program officials. In addition, the finding of a focus considered to be residual in beef cattle indicates that surveillance for brucellosis in at least beef cattle needs to be enhanced if possible.

The culturing of biovar 2 in Puerto Rico has generated considerable interest in the use of biovar as an epidemiological tool to establish the source of infection for the current outbreak. Tracing the outbreak to Juan Rivera's herd, which was, in part, of Texas origin, led to the possibility that the infection further traced to the Texas-origin cattle.

While biovar 2 may occur more frequently in Texas, it has also been known to occur at least twice in Puerto Rico. Puerto Rico receives from 3,000 to 10,000 head of cattle from the U.S. and Canada yearly, including a small number of beef cattle. (Puerto Rico Department of Agriculture) While cattle movements into Puerto Rico are now permitted only from states with low levels of brucellosis (Class Free and Class A), the potential for introduction of different biovars of *Brucella abortus* will continue to exist as long as these movements persist.

One previous case of biovar 2 identified in Puerto Rico involved a dairy herd in Hatillo. This adult-vaccinated 70-head dairy herd was determined to be infected in January 1982 with biovar 1. Upon whole-herd vaccination and a herd-owner change, the culture results also changed, to biovar 2. The source of infection for the biovar 1 infection was purchased dairy replacement animals from a herd in the Hatillo area which had been sold out. Biovar 2 results were considered a puzzle and there has been no connection established with other biovar 2 outbreaks.

The second herd was a small 8-cow beef herd, belonging to Pablo Silva and located in the northern municipality of Toa Alta. This herd was also positive on culture attempts for both biovar 1 and 2. All animals were purchased additions from the Melendez beef herd, located in Carolina and Canovanas in eastern Puerto Rico. The Melendez herd was under quarantine after June 1982. While the known infected group of the Melendez herd was depopulated in October 1982, additional infection was found in another group in January 1983. Apparently up to 100 head were dispersed to several beef cattle herds during the quarantine period. At least 32 herds with 1,300 predominately beef cattle were tested at the time. In addition to the Melendez herd, 3 herds were eventually found infected, based on serology and culture results.

While there were no culture results available for the Melendez herd, the assumption is made that the Melendez herd was infected with both biovar 1 and 2. While no direct connection has been established, it is felt that the Melendez case may well be related to the 1988 outbreak. This is based on presumed biovar 2 infection in the Melendez herd, the uncertain distribution of a large group of cattle, and some common trading partners. (Figure 1)

The Rivera herd was a double-premises mixed-origin herd and was composed of a local-origin beef-fattening herd and a purebred Charolais and Brahman herd. Record keeping was poor and there is no record of any local purchases of animals. Significant numbers of purebred animals had been brought in from Texas over approximately an 8-year period. Available copies of receipts, health certificates, and registration papers suggest that at least 66 head of cattle were brought in from 11 Texas herds during the period 1974 to 1981. The Rivera herd had been tested with Texas-origin card-testpositive reactors in 1975, but these were later attributed to residual vaccination titers. Available records for the herd are not clear on the final outcome of these and any other non-test-eligible animals that were in the herd at the time.

Past infection history or culture results for Texas herds which served as origin herds for the Juan Rivera herd were not available. The link to Texas, while still possible, has not been established.

In Puerto Rico, biovar 1 was the only finding until 1982, when biovar 2 was first cultured. Biovar 2 infection was found in 2 of 3 epidemiologically related herds in the current outbreak. Additionally, biovar 2 findings occurred in 1982 and 1983 in a dairy herd and at least in one small beef herd. While there is no clear association of past cases with the current outbreak, the nature of the 1982-1983 Melendez case certainly leads to speculation that the cases are linked. The introduction into Puerto Rico of biovar 2 remains unexplained.

The use of biovar an an epidemiological tool has permitted demonstration of a probable link for the current outbreak with a past case. The utility of the biovar marker was limited by the lack of laboratory and field data for presumed source herds, including herds outside of Puerto Rico. While infected cattle movements or other routes of exposure could not be proven, circumstantial evidence for a common source within Puerto Rico is present.

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3. Koneman EW, Allen SD, Dowell VR II, Sommers HM: Color Atlas and Textbook of Diagnostic Microbiology. J.B. Lippincott Company, Philadelphia, 1983.

4. Joklik WK, Willett HP, Amos DB (editors): Zinsser Microbiology. Appleton-Century-Crofts, Prentice-Hall, Inc., Norwalk, Connecticut, 1984.

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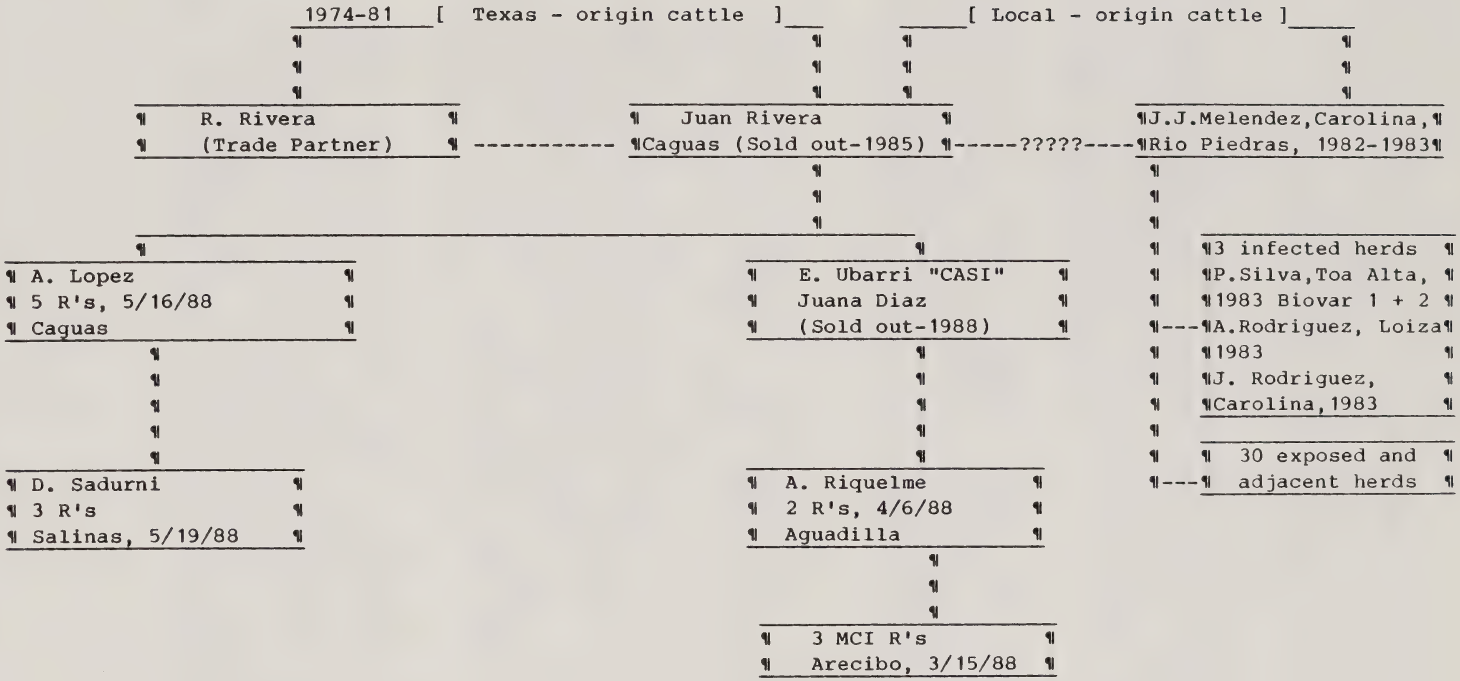
Table 1. Puerto Rico Cooperative Bovine Brucellosis Eradication Program: Historical Data.

Fiscal Year	Number of Reactors	Number Herds	Newly Infected Herds
1977	2179	157	87
1978	773	112	43
1979	693	84	36
1980	509	77	40
1981	435	62	29
1982	308	46	23
1983	191	41	20
1984	29	27	9
1985	3	3	2
1986	0	0	0
1987	0	0	0
1988	9 (to date)	3 (to date)	3 (to date)

Figure 1. Puerto Rico Brucellosis Infected Herds - Epidemiology, September 1988



USE OF THE PCFIA IN FLORIDA FOR BRUCELLOSIS TESTING

David Warner, DVM, USDA/APHIS/VS, Sebring, Florida

The PCFIA has been evaluated extensively in brucellosis negative cattle populations and in populations with various proportions of official calfhood vaccination. In Florida this assay has been largely used to evaluate a recently adult vaccinated cattle population. To date over 150,000 samples have been evaluated at the Sebring, Florida laboratory.

The PCFIA is a primary binding assay, more sensitive than the secondary binding assays (card, rivanol, CF) currently used to classify cattle for brucellosis. Specificity of the test in this population is greater than rivanol and less than CF. The PCFIA is mostly automated and therefore a large number of samples (about 1600) can be easily run in a day by one technician.

The simplified mechanics of the PCFIA are as follows:

(1) Polystyrene particles are coated with a crude antigen prep of strain 2308 (BASA). The coated particles are dispensed into microtiter-like plates with a membrane filter in the bottom.
(2) Test serum is added to the wells of the plate.
(3) Brucella-specific antibody attaches to the coated particles, other antibody washes through the membrane.
(4) Fluorescein labelled brucella-specific antibody (conjugate) is added to the wells of the plate.
(5) Conjugate attaches to free sites on the coated particles.
(6) Strong fluorescence (high meter reading $\geq$ 0.7) indicates negative sample. Weak fluorescence (meter reading $\leq$ 0.25) indicates reactor.

The PCFIA is used as part of a battery of tests. The presumptive test cutoff is 0.7, equivalent to the BAPA test. The cost, in excess of $1.00 per sample, precludes its use in Florida as a presumptive test as over one million on-farm cattle are tested here per year. Our testing procedure is to screen serum with BAPA or card test. Card positives are then subjected to rivanol and PCFIA tests. The PCFIA was chosen at the Sebring lab in lieu of CF due to space and speed considerations as mentioned previously; the tradeoff was decreased specificity compared to CF.

PCFIA technology offers some "extras" in that the PC is programmed to provide herd profile histograms to compare past and present results, etc. From a herd standpoint the profiles are of some predictive value, however, there is absolutely no predictive value for individual animals, unless perhaps the negative animals are maintained in a separate herd. This latter hypothesis has not been tested in Florida, however, it may merit further examination.

Now that the PCFIA has been accepted as an official brucellosis test, one of the everyday realities experienced at our laboratory will become apparent to more regulatory personnel. I am speaking of card positive animals moving in interstate commerce as a result of this. I have followed up 200 of these card positive animals on one or more subsequent tests, and have found no evidence of brucellosis in these animals to date. Further my gut feeling is that these animals are no riskier than card negative, PCFIA negative animals, vaccinated or not.

"Infectious laryngotracheitis epornitic", D. C. Johnson, DVM, Conyers, GA

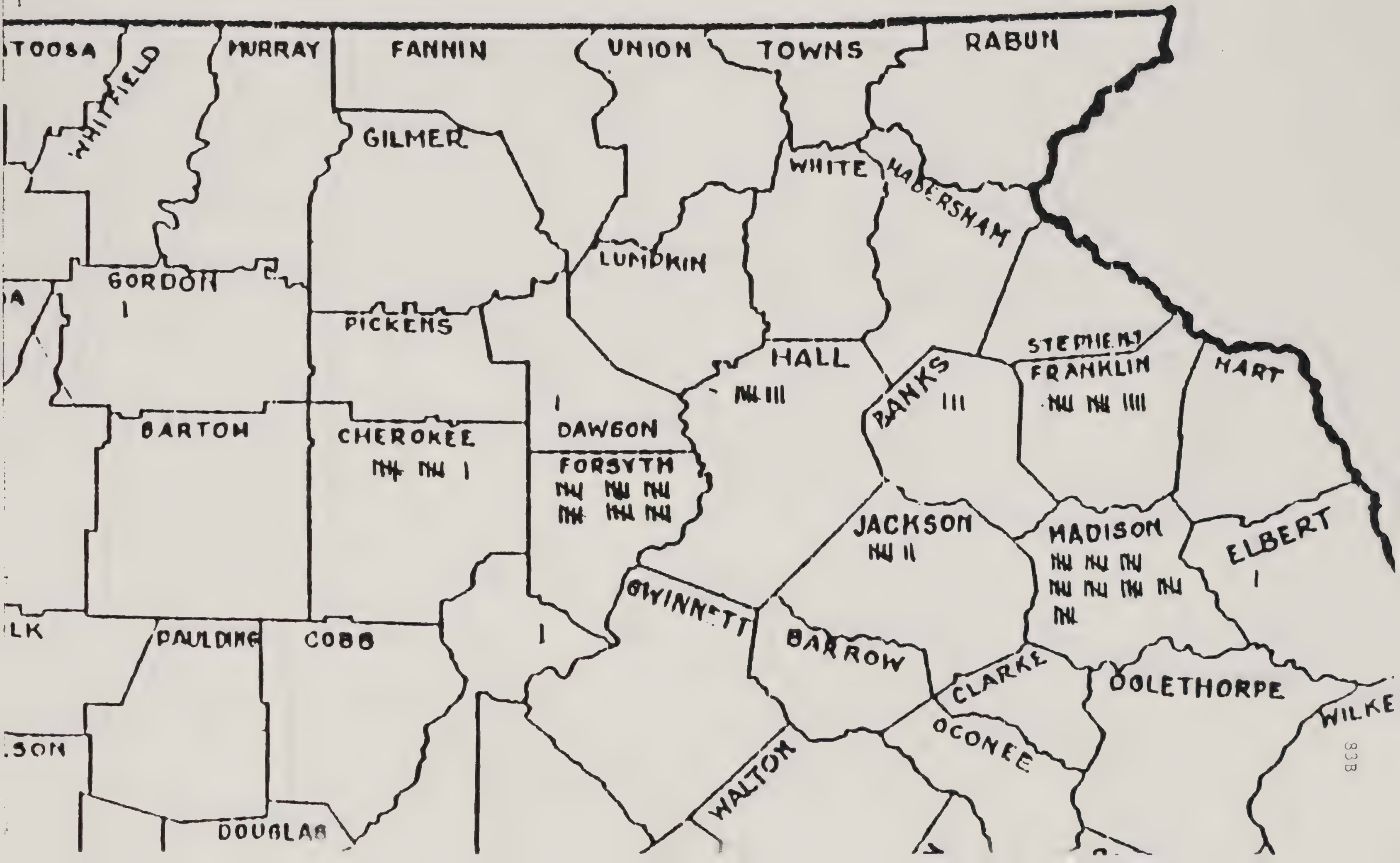
Infectious laryngotracheitis was confirmed in 118 flocks of chickens in eleven counties of north Georgia during the first six months of 1985. There were 102 broiler, 4 commercial egg, and 12 broiler breeder flock is infected. The flock infection rate peaked in April and May.

An epidemiologic study of the epornitic was conducted to determine the means of transmission. Several management practices were identified as contributing to the spread of the disease.

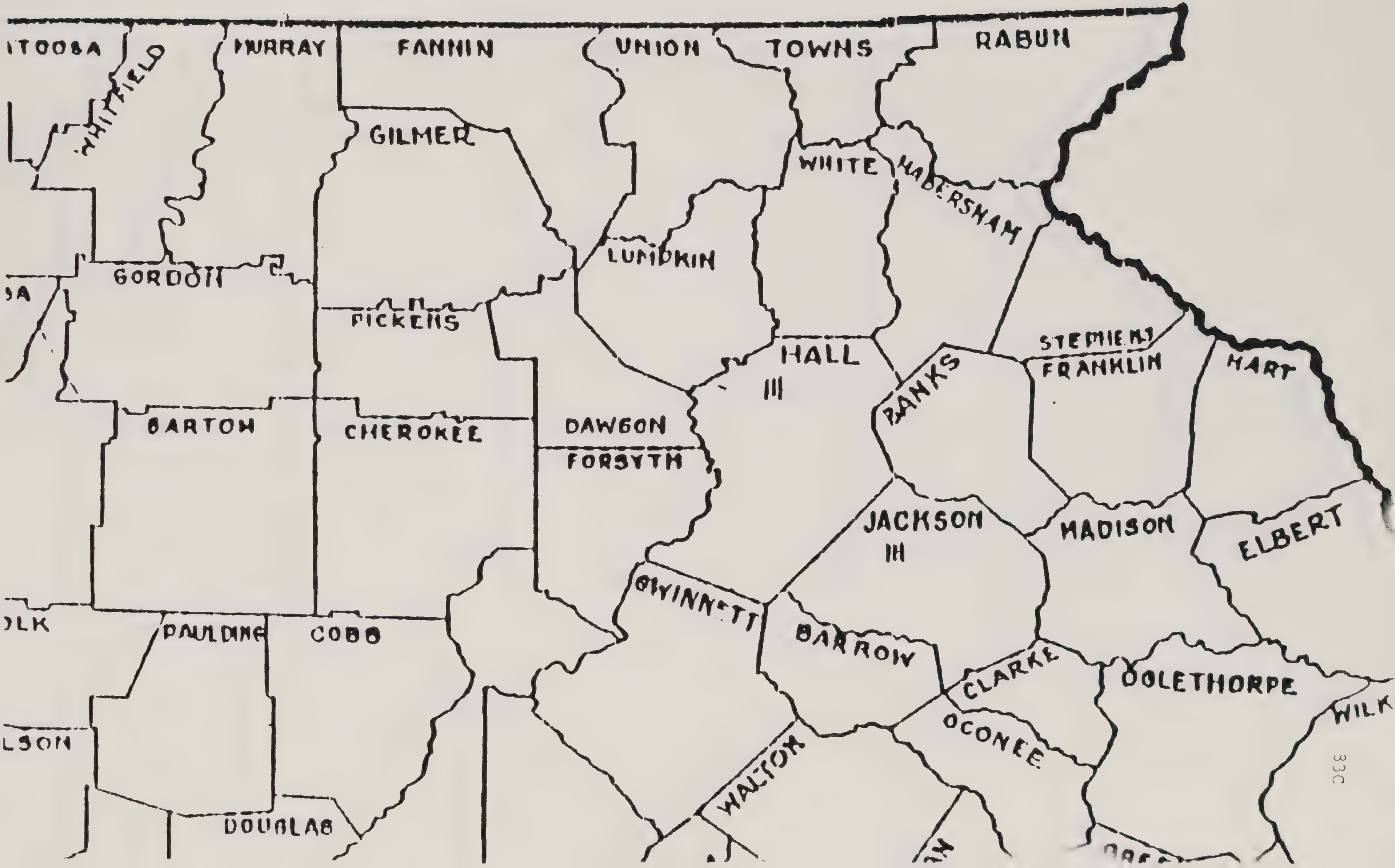
Infectious Laryngotracheitis in Northern Georgia - 1988: A Progress Report

- R. E. Pacer, VS - Tampa, FL

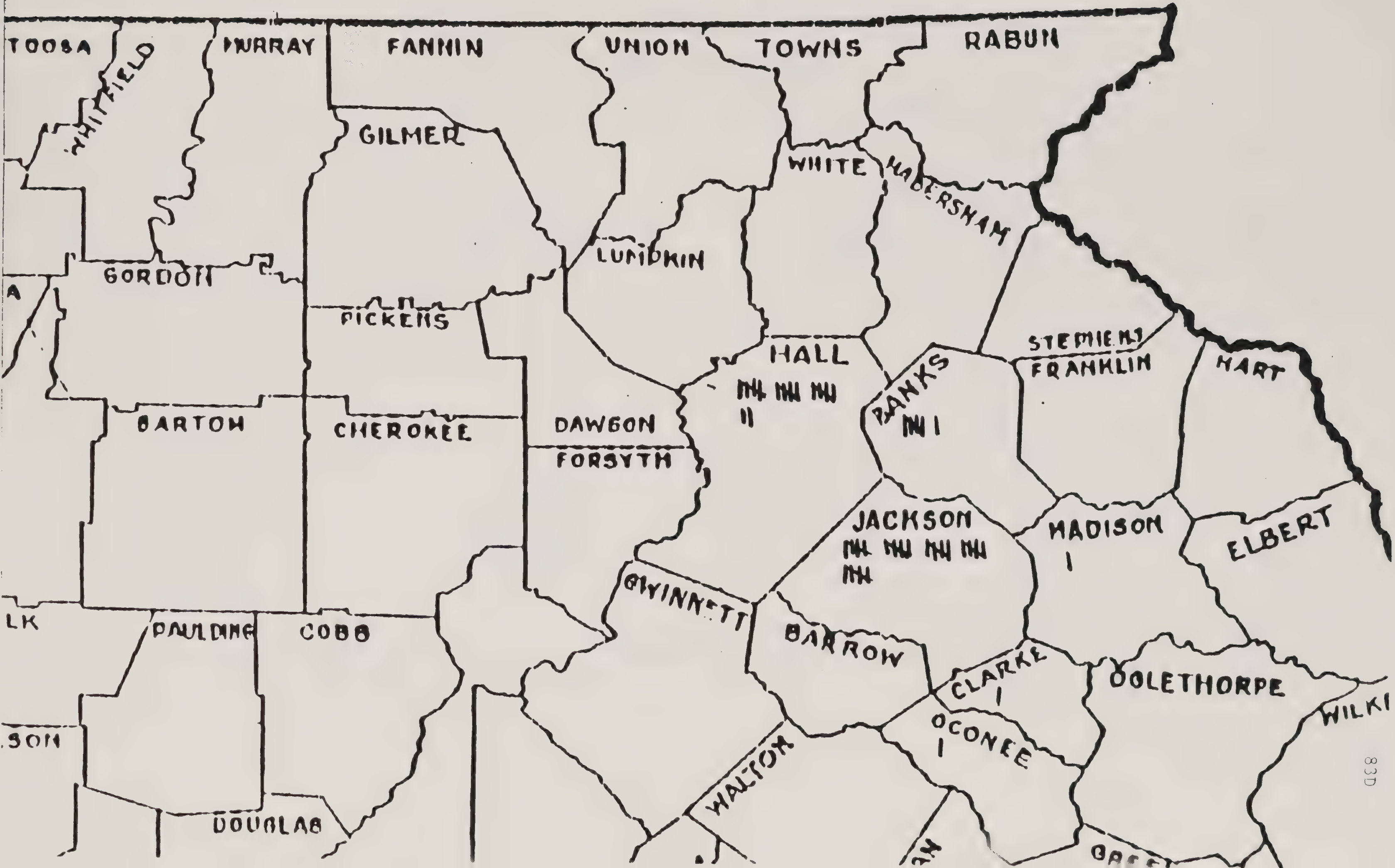
Cases of ILT by County
1985



Cases of ILT by County
1987



Cases of ILT by County
1988
(to May 21st)



INCIDENCE of INFECTIOUS LARYNGOTRACHEITIS

by AGE of FLOCKS

October 1, 1987 - June 1, 1988

WEEKS OF AGE		NUMBER OF FLOCKS 1987	NUMBER OF FLOCKS 1988
3		1	1
4		0	4
5		0	12
6		5	17
7		0	17
8		0	0
9-12		0	2
13-20		0	0
21-26		0	0
50+		0	1
	TOTAL:	6	54

GRAND TOTAL: 60

INFECTIOUS LARYNGOTRACHEITIS OUTBREAKS

TYPES of POULTRY AFFECTED

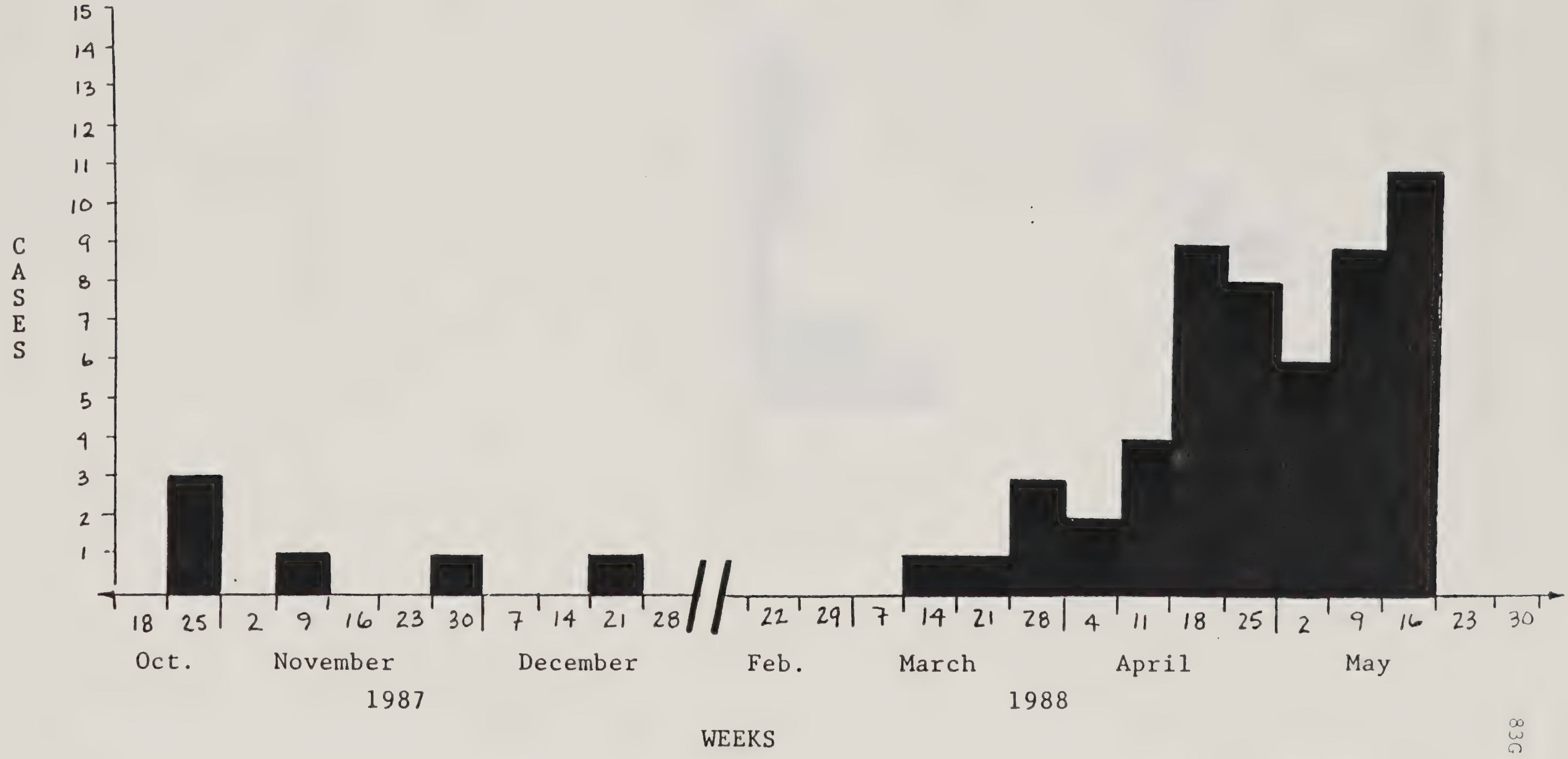
	1987	1988 (to 6/1/88)	
BROILERS	6	51	FLOCKS
COMMERCIAL EGG		2	FLOCKS
BROILER BREEDERS		1	FLOCK

AREAS INVOLVED

	1987	1988 (to 6/1/88)	
JACKSON COUNTY	3	26	FLOCKS
HALL COUNTY	3	18	FLOCKS
BANKS COUNTY		6	FLOCKS
MADISON COUNTY		2	FLOCKS
CLARKE COUNTY		1	FLOCK
OCONEE COUNTY		1	FLOCK

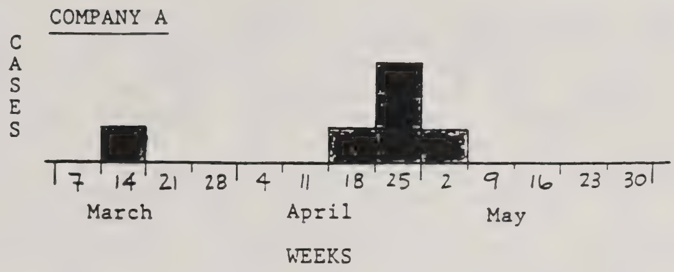
INFECTIOUS LARYNGOTRACHEITIS INCIDENCE by WEEK

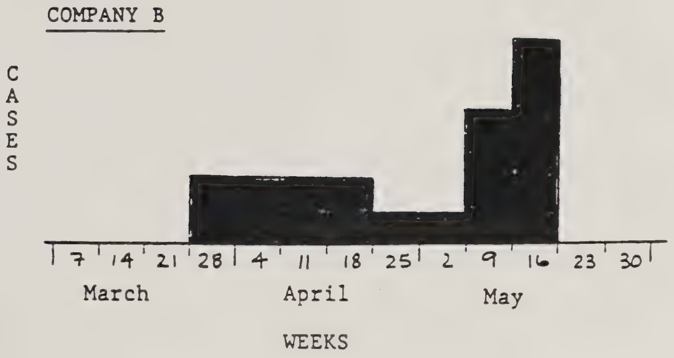
October 1, 1987 - June 1, 1988

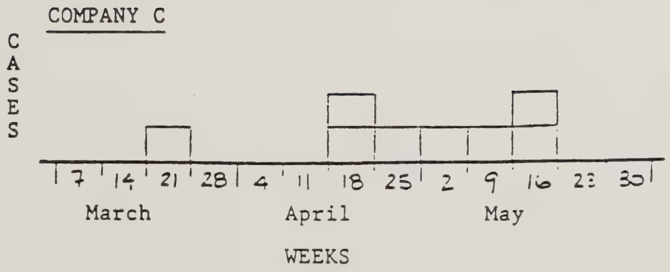


INFECTIOUS LARYNGOTRACHEITIS INCIDENCE by WEEK

March 1, 1988 - June 1, 1988







"Epidemiology of vesicular stomatitis in Mexico, field studies", J. Mason, DVM, MPH, Mexico City, Mexico.

This presentation reviews the monitoring and analysis of vesicular stomatitis (VS) incidence in Mexico during the last 30 years and the results of a 3-year epidemiological field study of VS in Mexico, and the continuation of this study at the present time on the Isthmus of Tehuantepec. Results of a study of the pathogenesis of VS in bovines carried out in Mexico and the findings of a "fingerprinting analysis" of VS virus isolates from Mexico is presented to provide an overall view of the current understanding of the epidemiology of VS in Mexico and the continuing efforts to elucidate the still unanswered questions about the means of transmission and the reservoirs of VS.

The Importance of Singleton Reactors to Pseudorabies Virus: A Retrospective Study

J.F. Annelli
R.B. Morrison
D.G. Thawley
University of Minnesota

INTRODUCTION

Pseudorabies (Aujeszky's Disease) was first reported in the literature in Hungary in 1902. Pseudorabies virus (PRV) is a herpes virus with cuboidal symmetry, an icosahedron of 162 capsomers, and an outer membrane making the complete enveloped virion about 180nm. PRV is fatal in all susceptible species of livestock except swine which are the natural host. Classical signs, which gave rise to the name, are similar to rabies with excessive salivation, fever, depression, intense puritis (hence the synonym mad itch), convulsions, and death. In swine, the disease is manifested by generalized neurological signs, respiratory problems, reproductive failure, decreased growth rate, and increased mortality. Severity of disease depends on the age of the pig, strain and dose of virus, and route of exposure.

Naturally occurring infections have been estimated to cause multimillion dollar losses annually in swine in the United States. These losses led to a motion that was passed at the May 1981 United States Animal Health Association Meeting establishing pilot projects to determine if eradication could be achieved. Reports from the PRV pilot projects confirmed that in individual herds of swine eradication could be efficiently achieved. A PRV task force with representatives from a variety of pork industry organizations including National Pork Producers Council, United States Department of Agriculture, Livestock Conservation Institute, Farm Bureau, and American Association of Swine Practitioners, developed a plan recommending national eradication of PRV. In March 1987, the National Pork Producers Association endorsed such an eradication plan. This National Pseudorabies Eradication Program is scheduled to begin January 1, 1989.

Detection of PRV infection is based on clinical signs or routine serologic testing for shipment or monitoring. Confirmatory diagnosis of clinical signs is by florescent antibody of tonsil or brain and/or serological tests. The two most often used serological tests are the enzyme linked immunosorbant serum assay (ELISA) and the serum neutralization (SN) tests. A latex agglutination test is also available and is receiving increased use. The latest technology in PRV eradication is a monoclonal antibody ELISA to be used with gene deleted vaccines to differentiate between vaccinated and infected pigs.

In a monitoring program one must weigh the cost of testing against the probability of detecting disease. Monitoring large numbers of herds will not involve testing all animals in a herd. To detect

with 95% confidence a herd in which there is at least a 10% prevalence of seropositive animals a representative sample of about 30 animals must be tested. This sampling method is what is used in most if not all current monitoring programs. The program used in Minnesota tests approximately 30% of the breeding herd up to a maximum of 30 animals.

Monitoring of a representative sample of animals or of an entire herd will occasionally reveal a single positive animal. Since spread of virus within the herd should infect more than one animal, it is thought unlikely that this herd is truly infected with PRV. To compound the problem of singleton reactors, it is not uncommon for herds to become infected despite the use of strict biosecurity measures and the source of PRV remains unknown.

THEORIES FOR OCCURRENCE OF SINGLETON REACTORS

Several seedstock herds from Minnesota had single reactors to PRV detected and yet complete herd tests failed to reveal evidence that PRV was spreading within the herd. Singleton reactors may be explained by one of four theories. Firstly, PRV may have recently been introduced into the herd, and the single reactor may be the first to seroconvert. Continued testing would be recommended in this herd to be sure all infected swine have been removed. Secondly, the herd may have been infected sometime in the past, and the singleton reactor is the last positive pig to remain in the herd. Again continued testing should be done to assure that there are no remaining infected pigs in the herd. The third possibility is that the singleton reactor is a false positive and the pig has never been exposed to PRV. This herd should not be quarantined and be considered negative for PRV since virus is not present in the herd. The fourth explanation is that the singleton reactor has been a seronegative latently infected animal that has now seroconverted and has the potential to infect others in the herd. This herd should be quarantined for PRV since there is potential for spread within the herd and among herds even if serology does not indicate positive animals. The problem is how to distinguish which of the four possibilities is correct and whether the herd needs to be quarantined.

IMPORTANCE AND IMPLICATIONS

Many state regulatory officials consider singleton reactors false positives on serological testing. There is strong evidence to suggest that a substantial proportion of singleton reactors are infected. To date, 32 herds in Minnesota have been identified as having had one or more singleton reactors since 1984. In order to avoid the expense that the label 'quarantined herd' would cost the producer, additional testing was developed for singleton reactors to determine if they are truly infected with PRV.

Twenty-two sows from these herds were subjected to a "Singleton Reactor (False Positive) Study" developed by the Minnesota Board of Animal Health and the University of Minnesota Veterinary Diagnostic

[illegible] a single positive [illegible] the test should infect more than one animal, [illegible] unlikely that this herd is truly infected with PRV. [illegible] the problem of singleton reactors, it is not [illegible] become infected despite the use of strict biosecurity [illegible] the source of PRV remains unknown.

[illegible] CONSEQUENCES OF SINGLETON REACTORS

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[illegible] AND IMPLICATIONS

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[illegible] from these herds were subjected to a "Singleton False Positives Study" developed by the [illegible] and the University of Minnesota Veterinary Diagnostic

Lab. This study consists of a dexamethasone suppression test (2 mg/lb IM dexamethasone for 5 days) with virus isolation, additional serology and histopathology attempted 3 days post suppression to rule out other causes for the original seropositive diagnosis. Four singleton reactor herds subjected to the "False Positive Study" had positive virus isolation and one later broke with PRV. One herd, having had negative virus isolation results, later broke with PRV. These five cases are discussed to demonstrate the problems facing regulatory management and eradication of PRV from some swine herds.

CASE HISTORIES

CASE 1: A 250 sow farrow to finish operation in total confinement with shower in shower out complete isolation biosecurety. This herd was started with a new company in 1984 as a seedstock producer. The new company required a complete herd test for PRV which was negative. The state of Minnesota allows seedstock producers to quarterly test one fourth of their breeding stock so that in one year all breeding animals would be tested. This herd's quarterly test results for the next year were negative. In September of 1985 on a routine quarterly test of 60 animals one was positive with a titer of 1:16. She and eight of her penmates were retested two weeks later. The original titer was now 1:32 and another pig was positive on ELISA but negative on SN. These two pigs were subjected to the dexamethasone suppression test. PRV was isolated from one pig and was typed at NVSL as field strain PRV, Funkhauser strain. The herd was quarantined and a complete herd test was done one month later in October 1985. A complete herd test of 244 sows did not reveal any positive animals. In order to be released from quarantine a second complete herd test one month later in November was negative. All gilts sold out of this herd for the next year had to be tested as a precautionary measure. A total of 1097 gilts were tested that year and all were negative. At the end of the year of testing they were again eligible for qualified negative status and did a complete herd test before returning to a quarterly testing system. Of the 248 sows tested all but one was negative. Another singleton reactor with a titer of 1:8 has apparently come from somewhere. This animal was subjected to the dexamethasone suppression test but no virus isolated. No quarantine was imposed since there was no evidence of infection other than serology and the herd was allowed to return to quarterly testing. Eight months passed with 180 of the 240 sows in the herd tested negative. On their next quarterly test eight of the 60 sows tested were positive with titers ranging from 1:16 to 1:32. One week later when the results of the test were known 13 penmates were tested and three were positive with titer ranging from 1:16 to 1:64. The original eight were again tested and had titers now ranging from 1:16 to 1:128. At this time a complete herd test of 225 sows was done and revealed 34 positive animals. The herd was and is currently quarantined for PRV. They are currently vaccinating their breeding herd to prevent losses from clinical signs. They hope to begin a clean up program soon to get of quarantine once again.

CASE 2: A 35 sow seedstock producer used dirt lots for breeding and gestation and an indoor open front farrowing facility. The qualified negative status of this herd was started in 1985 with a complete negative herd test. Quarterly testing of 11 sows (25% of the breeding herd) has been done in this herd since that initial test. In March of 1987 one of the 11 sows tested was positive at a titer of 1:4. Two weeks later on March 30th that sow and nine of her pen mates were retested. She again tested positively with a titer of 1:4. The dexamethasone suppression tested was tried with positive results. The SN titer after stress was elevated to 1:16, fluorescent antibody of tonsil was positive and virus isolation was positive after one passage. Fingerprinting of this virus at the National Veterinary Services Laboratory in Ames, Iowa revealed that the virus was not related to the BUK pseudorabies virus used in the Norden vaccine. The remainder of the herd was tested on April 27th and this time a different sow was positive with a titer of 1:8. This sow was sick with a fever at the time of testing and was subsequently remover from the herd. On June 1, 1987 a complete negative herd test (26 sows) was done followed by a second on July 7th (24 sows) which cleared the herd from pseudorabies quarantine.

CASE 3: A 35 sow herd seedstock producer finishing 300-400 head was housed in outdoor lots with a traditional farrowing facility. This herd was established in 1944 and completely repopulated in 1961 with all new stock. In 1984 when PRV monitoring in seedstock herds began the entire breeding herd of 35 sows was tested and was negative. Any addition to the herd, which is seldom, is tested negative twice before entering the herd. Since the complete negative herd test in 1984, quarterly tests of 25% of the herd have been done. All the results from these tests were negative until September 16, 1986. On a routine quarterly test of 6 sows, one was positive at a titer of 1:16. That pig was retested two weeks later and was now positive with titer greater than or equal to 1:32. Because of the history of negative tests in this herd and the reluctance of the owner to believe that his herd was infected a complete herd test was done on November 4th, 1986. At this time there were only 19 sows in the herd, eighteen were negative and the one positive remained positive at greater than or equal to 1:32. On November 24, 1986, after 5 days of high levels of dexamethasone and a 3-day waiting period, the sow was sacrificed. PRV was isolated from mink lung cell culture inoculated with composite brain, spinal cord, tonsil and trigeminal ganglion. The herd was quarantined on December 5th, 1986. This quarantine was released January 21, 1988 after two negative complete herd tests. The latest of these complete herd tests was December 3, 1987 when all 21 sows were tested. Since then another complete herd test of 16 sows was negative in February of 1988. This producer intends to regain his qualified negative status and hopes to again sell breeding stock.

CASE 4: A 500 sow combined total seedstock producer also sells feeder pigs as well as finishing a portion of the pigs themselves. This operation utilizes three farms, one for breeding and gestation (average inventory of 250 sows), the second for farrowing and nursery (average inventory of 250 sows), and the last for

growing/finishing. In May of 1982, 34 pigs were tested and two were positive at 1:4 and one had a titer of 1:2. A few weeks later 40 more were tested and three were positive at 1:4 or greater and five had titers of 1:2. A quarantine was issued on May 27th, 1982. All positive animals were moved to a different farm and the quarantine was released on the first and applied to the second. This second farm was released from quarantine on December 7th, 1982.

Two years later, in 1984 when PRV monitoring of seedstock producers for qualified negative status began, this herd did a complete herd test that was negative. Quarterly testing was started to maintain the qualified negative status as well as testing all gilts sold for seedstock from this herd. Each farm was treated as a separate entity for the purposes of PRV monitoring. Nine separate tests totalling 231 pigs were done on one farm over a period of 6 months. In December 1984, on a routine quarterly test of 31 sows from that farm, 16 positives were identified. Two of the herd's three farms were again quarantined and an additional 20 hogs were tested. All 20 of these hogs were positive and immediately sent to market. During January and February a total of 182 sows were tested and all were negative. The quarantine was released on the first farm. In April the 38 sows on the second farm were tested and all were negative. The quarantine was released April 18, 1985 on the second farm and things seemed to be back to normal. Quarterly testing and test of all sales was resumed. On June 28, 1985, 86 gilts for sale were tested and one was positive with a titer of 1:2. A complete herd test of 259 sows was done as soon as the one positive was identified. All were negative. The 11 herd boars were also tested. They were also negative. The positive sow was retested and was now positive with a titer of 1:4. The decision was made to immunosuppress this sow. On July 29th, 1985 the sow was submitted to the University of Minnesota veterinary diagnostic lab. Virus isolation as well as FA of tonsil, brain, spinal cord and trigeminal nerve were negative for PRV. The original serology, since it was a very low titer, was considered a false positive. To be safe the state required 3-4 months of monitoring before allowing the sale of breeding stock. During the next 3 months, 198 hogs were tested and all were negative. The herd regained it's qualified negative status on October 22nd, 1985. Quarterly testing as well as the testing of all breeding stock sold continued with negative results until 1987.

In January of 1987, a total of 165 sows were tested and all but one was negative. This second singleton reactor in this herd had a titer of 1:16 and was stressed with all results being negative. Quarantine was released but the herd dropped it's qualified status and only tests gilts for sale as breeding stock. In April of 1987 another singleton reactor, the third in this herd, was found. The gilt was one out of a group of 78 tested and had a titer of 1:4. Another 42 tested a few days later were all negative. The one positive gilt was stressed and all results were, once again, negative. The herd continued as before with testing all gilts for sale which averaged 100 or more every month. A few months later on August 11th, 1987 the fourth apparent 'false positive' in this herd turned up. This time 37 gilts were being tested and one was

positive with an SN titer of 1:4. With the history in this herd by this time an immunosuppression test was done. Fluorescent antibody of tonsil was positive and coculture of trigeminal nerve, tonsil, brain, spinal cord yielded positive pseudorabies virus isolation. A complete herd test was done of 177 sows on August 31st, all were negative and the quarantine was released. Once again 100 or so gilts for sale were being tested each month with negative results until February 9th, 1988. On the now routine testing of gilts, 49 were tested and one, the fifth singleton reactor, was positive with a titer of 1:8. She was subjected to the dexamethasone suppression test and tested negative. One month later in March, 48 more gilts were being tested prior to sale and once again one was positive, this time with a titer of 1:16. The gilt was retested in April and was now negative so no stress test was done and the gilt was sold. There has since been a seventh singleton reactor in this herd but the information is unavailable. Testing continues and we will continue to monitor this herd.

Case 5: A 60 sow herd seedstock producer uses three farms used for overall operations. In 1982 this herd was quarantined for pseudorabies and was released soon after by offspring segregation. This was not a qualified negative herd but was testing all sales of gilts for breeding since 1982 with all negative results. In February of 1987, 61 such gilts were tested and one was positive at a titer of 1:8. When this gilt was retested she retained her 1:8 titer so she was put through the stress study. The results of this dexamethasone suppression study was negative, no FA or virus isolation only seropositive results. A complete herd test of the 70 breeding sows was negative and the herd was released from quarantine. They continued testing 50-60 gilts per month with negative results until 11 months later in December of 1987. Another 73 head for sale were being tested when one was positive at a titer of 1:4. This pig was stressed and sent to the lab for testing again with negative results. A few months later in March of 1988 another test for sale was done of 25 pigs. This time 24 of the twenty-five pigs were positive. Additional testing revealed almost 100% infection in this herd. They are currently quarantined.

DISCUSSION

The occurrence of singleton reactors is rare but as the prevalence of PRV decreases from the eradication program, the importance of singleton reactors will increase. Total eradication would be impossible if singleton reactor herds represent truly infected seronegative herds with the potential to shed virus and spread infection. The majority of these herds would test negative on current methods until conditions were right for one or more animals to seroconvert and possible spread infection. This may be the case in the United Kingdom which considers itself free of PRV for some time now after a very expensive eradication program. Despite this free status there have been many singleton reactors detected on slaughter surveillance. When a seropositive animal is detected at slaughter, a traceback to the herd of origin is usually negative.

These singleton reactors are considered by many to be false positives since no infected herds have been traced back. Despite this free status four clinical cases of PRV have been confirmed in 1988 and they do not know where they came from. This problem of 'false positive singleton reactors' has led the U.K. to a change from monitoring sows to monitoring boars at slaughter. This decreased the number of singleton reactors but our information indicates that this change may miss some truly infected herds.

Case 1 and 5, both of which broke with PRV and are currently quarantined, are good examples of the potential damage singleton reactor herds may represent. Only one of these herds had virus isolated after the stress test but both broke. This may indicate a failure to isolate virus from the latent state. Not all cases that have had virus isolated from the herd, as in case 2 and 3, have had PRV problems. The problem with this is even if virus is isolated the proper method to deal with the herd is still unknown since PRV was not a problem. Case 4 makes the confusion greater by having many singleton reactors, no problems associated with PRV and has had a positive virus isolation.

CONCLUSION

The problems presented could be well explained if the theory of a seronegative latently infected animal were correct. In order to prove this and work out a regulatory management scheme for these herds additional work needs to be done. Attempts to experimentally recreate a seronegative latently infected pig must be attempted. Improved methods of detecting latent viral infection must be developed to study the epidemiology of latency. Alternate confirmatory tests must be developed to augment the SN and ELISA tests in the singleton reactor herds. These test must also be developed to be used as a screen for the seronegative latently infected swine that may remain within a herd after infection. Once these tests and theories are explored a decision tree must be developed in order to more accurately make decisions regarding the regulatory management of singleton reactor herds in the eventual eradication of pseudorabies from all swine in the United States.

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Summary of the Economic Studies of the Pseudorabies Pilot Projects

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The economic studies of the pseudorabies eradication pilot projects were implemented to aid in making the decision to either eradicate or live with the disease. Alternative clean-up methods to eradicate the pseudorabies virus (PRV) from infected herds were evaluated. Preliminary results from the pilot projects have provided momentum for implementing pseudorabies control programs and possible eradication. The evidence of this is the September 11, 1986, draft of "PRV Control/Eradication Plan," designed under the guidance of the Livestock Conservation Institute (LCI) and promoted by the pork industry.

The five pilot project studies have the following objectives:
(1) document costs of pseudorabies to producers, (2) estimate costs to producers of eradicating pseudorabies, and (3) estimate the public costs of eradication. The research for these studies was conducted by Dr. John Ambrosius in Wisconsin, Dr. Arne Hallam in Iowa, Dr. Loren Ihnen in North Carolina, Dr. H. Louis Moore in Pennsylvania, and Dr. Allan Mueller in Illinois. Dr. James Kliebenstein also conducted an economic study in a large, multiple-unit confinement operation. A summary of the methods used for data collection will be provided by the author when requested.

Caution must be exercised in the use of the results of the economic studies. The advantage of actual data from producers° on-the-farm experience with pseudorabies comes with disadvantages. Management styles and recordkeeping vary from farm to farm and have an effect on the data collected. Still, it is data from the real world, not from controlled experiments conducted in somewhat artificial environments. Comparison of results between pilot projects must be made with the understanding there are differences in the pork industry among states and differences in the eradication programs among states.

Herd Infection Rates

The cost of eradicating a disease from an area, state, or country is greatly dependent on the number of herds that are infected. The pilot projects provide some basis for estimating the number of herds infected with pseudorabies virus. As Table 1 indicates, large herds have a greater herd infection rate than small herds. Approximately 50% of the infected herds in the Illinois (IL) and Iowa (IA) pilot projects were herds with over 100 sows. However, the 1982 Census of Agriculture reported more than 80% of the herds in Macoupin and Pike Counties of IL and Marshall County of IA had less than 100 sows. A random sample of pseudorabies-negative farms in Marshall County had an average herd size of 60 sows. This agrees with the Census of Agriculture in that most pork producers in Marshall County have less than 100 sows.

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The pseudorabies herd infection rate is greater in the IL and IA pilot projects than in the Pennsylvania (PA) and Wisconsin (WI) projects. The IL pilot project covered 5 and 3 townships of Macoupin and Pike Counties, respectively. There were 174 herds tested in these townships, of which 32 were determined infected on initial test, for a herd infection rate of 18.4% (Table 2). One herd was positive on a surveillance test after the initial negative test for a total of 33 infected herds. At the initiation of the pilot project area testing, 16 of the 32 infected herds were known and under quarantine. As of June 1986, there were 436 herds quarantined in the State of IL. An expansion factor of 2.0 (32/16 = 2.0) suggests there are 872 pseudorabies-infected herds in the State (2.0 X 436 = 872). An alternative calculation using the 18.4% herd infection rate suggests there are more than 1,100 infected herds in the state. Twenty counties in IL have a rate of quarantined herds similar to that of Macoupin and Pike Counties. There are an estimated 957 infected herds in these counties, assuming they have 5,200 herds (5,200 X 0.184 = 957). There are 85 quarantined herds in the other 82 counties. Assuming 170 infected herds (2.0 X 85 = 170) in these remaining counties provides the estimate of 1,127 infected herds in the state. Between 870 and 1,100 infected herds in IL is the estimate suggested by the pilot project data.

The 14.6% herd infection rate for Marshall County, IA, is a prevalence rate at a point in time—December 31, 1983, (Table 2). Of 185 herds tested, there were 27 infected herds. After December 31, 1986, three additional infected herds were discovered on initial test. During the pilot project, 10 herds were found infected after being negative on an earlier test for a total of 40 infected herds.

Two assumptions are implied when the prevalence rate of 14.6% is extrapolated from Marshall County to the entire state: (1) Marshall County is representative of the state, and (2) pseudorabies is endemically stable in IA, with as many herds becoming free of pseudorabies virus as there are herds becoming newly infected. It follows that there are 5,548 pseudorabies-infected herds in IA (38,000 X 0.146 = 5,548). Twelve of 30 infected herds were known infected and under quarantine at the initiation of the pilot project area testing. As of August 1986 there were 2,205 quarantines of record in Iowa. An expansion factor of 2.5 (30/12 = 2.5) suggests there are 5,512 pseudorabies-infected herds in the state (2.5 X 2,205 = 5,512). These 2 estimates are close to each other.

The annual incidence rate of negative herds becoming infected in Marshall County, IA, was 3.72%.

$$\frac{\text{10 newly infected herds}}{\text{153.6 negative herds X 1.75 years}} = 3.72\%$$

The available data are insufficient to estimate a herd infection rate or number of infected herds in North Carolina (NC). There have been approximately 40 known infected herds under quarantine. There are also approximately 20 herds in which vaccine is known to be used that are seropositive and under quarantine. The pseudorabies slaughter surveillance program in NC is not reliable. During July and August 1986, 168 blood samples collected at slaughter were pseudorabies positive, but only 34 had

identification. There is 70 to 80% successful tracing of identified samples to the herd of origin. Tracing 26 (0.75 X 34) of 168 positive blood samples is evidence that swine identification is still a major problem.

The herd inventory for Lancaster County was used as the denominator for the herd infection rate of 8.1% in PA (Table 2). Infected herds found outside Lancaster County have been feeder pig finishers found when feeder pig sales are traced from infected herds in the county.

During 1984 and 1985, pseudorabies has been primarily in four counties of WI, with a herd infection rate of less than 2% (18/1700 = 1.1). During 1984, 10 of the infected herds were in Lafayette County, which would be a herd infection rate of 2.6% in that county (10/381 = 2.6%). The assumption is made that 40 infected herds in PA and 18 in WI are reliable indications of the number of infected herds in those states during 1985.

Producer Costs of Pseudorabies

Approximately 50% of the producers with pseudorabies virus (PRV) infected herds did not experience clinical outbreaks (Table 3). The costs to producers of pseudorabies outbreaks are itemized in Table 4. The losses occurring in the farrowing house and mortality in pigs after weaning were combined into one estimate in the PA study. Lost sales of seedstock and feeder pigs were the two largest losses in PA and WI, whereas in IA, where most producers raise hogs for the slaughter market, this loss was not reported. Loss of sales would occur on all farms quarantined, not just farms that have clinical outbreaks. Deaths in nursing pigs and before birth were substantial losses in IA and WI. Abortions caused greater losses in IA compared to WI.

Pigs that become ill with pseudorabies but do not die grow slower than normal and are known as "backward pigs." This condition was reported in IA, PA, and WI, with the greatest loss occurring in PA. Other livestock losses in PA consisted of 13 dead steers ($6,162), which involved five farms. Another farm lost eight dairy heifers ($8,000). A $400 litter of purebred puppies also died because of pseudorabies.

The average costs of $35 and $33 per sow of a pseudorabies outbreak in IA and WI are comparable. The cost per sow of $105 to PA producers is more than double the cost in IA and WI because of the loss of feeder and seedstock markets. If these two items are deleted, the cost per sow in PA would be less than $40. Six of the 41 herds surveyed in PA raised and sold seedstock. The $138-per-sow cost of a pseudorabies outbreak in IL was derived from a simulator model. Estimates by three veterinarians and four producers on the losses due to pseudorabies were entered into the computer. The model then indicated the annual return above feed costs decreased $138 per sow due to pseudorabies.

Kliebenstein, et al., studied a vertically integrated, large pork producing enterprise. Data were analyzed from 7 herds infected with PRV. Four noninfected herds, plus the records from infected herds prior to their first pseudorabies outbreak, served as controls. Statistical analysis of the data

indicated a 5.28% decrease in number of pigs weaned per litter during a pseudorabies outbreak. The standard deviation was 0.5 significant at the 1% level.

Increased number of mummies, decreased number of pigs born live, and mortality of nursing pigs significantly contributed to the 5.28% decrease in number of pigs weaned per litter. The increases in number of stillbirths, pigs with scours, and pigs overlaid by sows were not statistically significant. Abortions due to pseudorabies were not reported from this herd.

These losses became a direct cost of $11 per sow. Death loss in the farrowing phase causes vacant floor spaces in the growing-finishing units. The unrealized income resulting from these nonfilled spaces is an indirect cost due to pseudorabies calculated to be $16 per sow. The cost of pseudorabies in the farrowing and nursing phase of this operation is estimated to be $27 per sow (11 + 16).

The effect of pseudorabies in the finishing phase of this operation was minimal. The base used for comparison was groups of pigs not known to have pseudorabies in either the farrowing or growing-finishing phase. Slight decreases in percent liveability, feed efficiency, and a slight increase in percent pigs condemned or dead on arrival at slaughter were reported in groups of pigs negative for pseudorabies in the farrowing phase but broke with the disease in the growing-finishing phase. However, these differences were not statistically significant. The cost of producing a hundredweight (cwt) of pig was $0.88 more in this group of pigs over the control group.

Groups of pigs from farrowing units positive for pseudorabies that did not experience a break during the growing-finishing phase showed only a $0.09 per cwt cost of production increase over the controls. Pigs positive in farrowing units and that broke with pseudorabies in the growing-finishing phase showed a $0.06 per cwt decrease in cost of production. The effects of pseudorabies during the growing-finishing phase were not statistically significant in this enterprise. This is different from the empirical observations of "backward" pigs in the pilot projects and increased incidence of "pseudorabies" pneumonia on the finishing floor reported by some veterinarians.

The producers surveyed in IL and PA spent only minor amounts for isolating and testing herd additions ($9 per herd in PA). IA was the only state in which the use of vaccine was promoted and therefore was the only state in which vaccine was commonly used by producers. Their vaccine costs averaged $317 per herd. Producers in IA also spent $277 per herd to isolate and test herd additions.

WI producers who had prior experience with pseudorabies and had freed their herds of the virus spent $814 per herd per year preventing reintroduction of the virus into their herds. The expense was for isolating and testing herd additions. Producers in WI without previous experience with pseudorabies spent $56 per herd per year to isolate and test herd additions. This amount did not vary with producers' proximity to or distance from infected herds.

Producer Costs of Eradicating Pseudorabies

There are 3 types of eradication plans, (1) test and removal, (2) offspring segregation, and (3) depopulation-repopulation (see LCI pamphlet, "Swine Pseudorabies Eradication Guidelines 2nd ed." for the plans). The plan used in a herd depends on several factors. The preference of regulatory veterinarians varies between states. Owners of quarantined herds have reasons for preferring a certain plan. The status of PRV in a herd may determine which plan is the most feasible. Testing the herd and selling positive animals with minimal other eradication measures is not an effective plan in herds with a high percentage of reactors and in which the virus is cycling. Depopulation-repopulation often is an efficient plan for infected feeder-pig finishing type operations. The incorporation of vaccine into a plan may increase its efficiency and is often used in the offspring segregation plan.

Data with more detail are available from the IA pilot project (Table 5). Five herds were freed of PRV using the "test and removal plan" at a producer cost of $93 per herd, or $1 per sow. The only cost to the producers was labor for testing and vaccinating. Quite likely PRV was not cycling in these herds, which simplified cleanup. Vaccine, veterinary service, and laboratory diagnosis were furnished through government funds, as they were in the other plans.

The 14 producers whose herds were freed of PRV using the "offspring segregation with controlled vaccination plan" did sell some breeding stock before normal culling age at a cost of $3,227 per herd. Other costs were primarily for extra labor. Facilities for segregating clean offspring from the positive herd were not an expense to these producers. They had vacant facilities that were brought into use to carry out the plan. Time required to clean up averaged 16 months.

Downtime was the primary cost to the 1 producer using the "depopulation repopulation plan" to clean his farrow to finish herd. This is also true of this plan as used in the other states. This producer reduced downtime to 13 weeks by purchasing replacements and keeping them segregated before depopulating his positive herd. He started on an offspring segregation plan before depopulating, which is the reason for the $900 cost for labor to vaccinate.

Depopulation-repopulation is a very efficient plan to clean up feeder pig finishing operations. The producer cost per pig was only $0.30 for 3 herds freed of the virus by this method. The $490 cost for segregating recently purchased feeder pigs was for 1 producer who routinely isolated new feeder pigs to prevent introduction of swine dysentery into his herd. This cost was prorated to PRV eradication.

Table 6 shows the producer's cost of eradication in other states compared to the offspring segregation plan in IA. Downtime for depopulation-repopulation in PA averaged 7.4 months, which cost the producers $39,072. Downtime is the most expensive item in WI even though herds cleaned of PRV by test and removal without downtime were included in the average downtime cost. The cost item "depopulated" in Table 6 is the value of the breeding animals depopulated

minus their salvage value at slaughter. The $53,937 cost for downtime and depopulation in IL was calculated by the simulator model for a 100-sow herd that farrowed 10 times per year. The cost was calculated as reduced returns above feed cost. The replacement of sows depopulated by bred gilts was factored into the model as well as production foregone because of depopulation. Dr. Mueller estimated 10 years would be required before a repopulated herd would recoup the costs of depopulation as compared to a vaccinated herd living with disease. He used a 10% discount rate.

The offspring segregation plan was not used in PA. The test and removal plan was used some in WI. The cost between breeding value and slaughter price of positive animals sold in WI under this plan is listed as a separate cost item.

Public Costs of Eradication

In the IA project, private practitioners were relied on to collect blood samples on the farm and to accomplish the vaccination part of the program. The practitioners were paid $15 per farm call (maximum of 1 call per month), $2.50 per blood sample for the first 10 samples and $2.00 for each sample more than 10, $0.05 per ear tag used, and $1.25 per dose of vaccine. The laboratory fee for the SN (serum neutralization) test was $1.00 per sample. For comparison, in NC the cost was $0.90 per SN test, and the ELISA (enzyme linked immuno-sorbant assay) test was $1.26 each. Also, in NC the average cost of fee basis testing by practitioners was $2.17 per sample.

Table 7 lists these costs for pseudorabies negative and positive herds in IA. Surveillance in the pseudorabies negative herds included blood collection and laboratory fees. The cost of vaccination in negative herds is itemized separately because it is not a necessary part of a pseudorabies eradication program. Government-funded vaccination was used in negative herds to gain the cooperation of these producers in the program.

The costs for positive herds include the cost of vaccination because it was an integral part of the eradication plans, especially Plan B, offspring segregation. The costs per sow and per herd are more meaningful than the total project costs.

Table 8 shows different accounting methods were used in the different projects. The expenditures are probably high. The projects are pilot with an objective of developing a more efficient and economical eradication program. Expenses are understandably greater during the learning process. In general, the project budgets vary with the number of herds involved.

Benefits of Eradication

Obvious benefits of eradication to producers are to avoid the losses and costs due to the disease and to avoid costs of prevention. An indirect benefit, especially to seedstock producers, is to reduce to zero the risk of their herd becoming infected.

The benefit of eradicating pseudorabies to society is a reduced price of pork to consumers. Eradication of pseudorabies will improve the pork industry°s efficiency in producing pork. More pork can be produced with the same amount of inputs of production. According to the T. A. Hieronymus model cited by Mueller, for each 1% increase in the supply of pork, the price of pork will decrease 1.83%. This decreased cost of pork production, with a concomitant decrease in price, will make pork more competitive with poultry and other meat products.

Discussion

The success of the 3 eradication plans requires the advice and monitoring by a veterinarian experienced with pork production and with pseudorabies. This requirement is more obvious for the offspring segregation plan because veterinarians are less acquainted with this type plan to eradicate a disease. The test and removal plan is commonly used in brucellosis eradication, and depopulation-repopulation was the principal plan used for hog cholera eradication. Veterinarians must be knowledgeable about the 3 plans before they can advise a farmer as to the advantages and disadvantages of the plans and then help him set up a plan. The offspring segregation plan requires regular monitoring over an extended period of time to be successful.

Most producers with infected herds in PA and WI would prefer to live with the disease rather than to eradicate. Whereas approximately 50% of infected herds in the pilot projects sustained clinical losses due to pseudorabies, 100% would have eradication costs under an eradication program.

Hallam explains in economic terms the preference producers with infected herds have to live with the disease rather than eradicate. He calculated the present values (PV) for pseudorabies outbreaks in positive herds and in clean herds and the PV for perpetually vaccinating sows. He used the costs derived from the pilot project in Marshall County, IA, and a 10% discount rate. Producers with positive herds are assumed to experience outbreaks every 12.5 years (8% annual incidence rate of outbreaks). Using the outbreak cost of $35 per sow (Table 4), the PV of outbreaks in infected herds is $28.50 per sow if the herd experiences the next outbreak 6.25 years from now and then an outbreak every 12.5 years. Vaccinating sows twice a year at $1.00 per head has a PV of $20 per sow. Thus, the IA data indicate it is cost effective for producers with infected herds to vaccinate. However, the average cost to producers to eradicate PRV from their herds is $29 per sow (Table 5), which is more than the PV of vaccinating.

The impetus for a pseudorabies program must come from producers with PRV-free herds, including seedstock producers. The assumption is made that 85% of the herds in IA are PRV free (14.6% herd infection prevalence rate). The annual incidence rate of clean herds becoming infected is 3.72%, i.e., 1,207 of the 32,452 clean herds become infected each year. Only 42.5% of these newly infected herds would experience clinical outbreaks. The PV of outbreaks in clean herds is $1.78 per sow if the first outbreak occurs 31.6 years from now and then an outbreak occurs every 63.2 years. The PV of an outbreak in a 60-sow herd is $106.80. The cost of eradication to producers with clean herds

in the IA project is $30 worth of labor for 3 monitor tests of 25 sows each during the 27 months of the project (5 hr labor X $6 = $30). Producers with PRV-free herds have an incentive to support an eradication program.

Seedstock producers° PV of physical losses due to a pseudorabies outbreak is estimated to be $5.92 per sow if the first outbreak occurs 31.6 years from now and then every 63.2 years. The PV of sales restriction of seedstock due to a 1-year quarantine is $87.56 per sow. Seedstock producers have sales restriction losses when their herds become pseudorabies positive even if they do not experience a clinical outbreak. Multiplying these PV°s of pseudorabies losses times a 60- or 100-sow herd makes it obvious why seedstock producers are such strong advocates of eradication.

Price discrimination against market hogs from pseudorabies infected herds was minimal. The cost during 1985 to WI producers to comply with the IL feeder pig law was 30 cents per pig for testing 128,331 pigs, which is equal to $38,499. Four to 5 hours of labor are required to properly clean and disinfect a truck after hauling pseudorabies infected hogs. A PA meat packer reported the prevalence of arthritis, pneumonia, and abscesses was higher in hogs from pseudorabies infected herds. This caused more trimming and a higher rate of condemnation and is an added direct cost of pseudorabies to farmers who sell on grade and yield.

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Table 1. Number of Pseudorabies-Infected Herds by Herd Size (1984-1985) Compared to 1982 Census of Agriculture Inventories, Illinois and Iowa Projects

Herd size number of sows	Illinois		Iowa	
	Number of infected herds	Number of herds, census	Number of infected herds	Number of herds, census[b]
1 - 24	6	412	1	85
25 - 49	7	211	2	65
50 - 99	6	193	11	66
100+	14	169	23	42
FPF[c]			3	

[a]Macoupin and Pike Counties

[b]Marshall County

[c]FPF = Feeder pig finisher, no sows on the farm

Table 2. Pseudorabies Herd Infection Rates in the Pilot Project States, 1984

Pilot project	Number of herds	Number of infected herds	Herd infection rate
Illinois	174	32	18.4
Iowa	185	27	14.6[a]
North Carolina		?	
Pennsylvania[b]	508	41	8.1
Wisconsin[c]	1 700	18	§ 2.0

[a]14.6% is the herd infection prevalence rate on December 31, 1983. Herd infection rate is 18.1% when calculated by using 40 infected herds per 221 total herds tested.

[b]Lancaster County

[c]Lafayette, Green, Sauk, and Grant Counties

Table 3. Percentage of Infected Herds Surveyed in the Economic Studies that Experienced Clinical Outbreaks of Pseudorabies, 1984 and 1985

Pilot project	Number of infected herds	Number with clinical outbreaks	% clinical outbreaks
Illinois	32	?	
Iowa	40	17	42.5
North Carolina	15[a]	8	53.3
Pennsylvania	41	24	58.5
Wisconsin	27	6	22.2

[a]The 12 infected feeder pig finishing units surveyed are not included, 3 of which had clinical outbreaks.

Table 4. Per Herd Cost to Producers Who Had Pseudorabies Outbreaks, 1984 & 1985

Item of loss	Iowa	Pennsylvania	Wisconsin	Illinois
	$			
Nursing pig mortality	1,920		395	
Stillbirths	644		119	
Infertility of sows	159	3,863[a]	94	
Abortions	1,154		78	
Growing pig mortality	29		40	
Backward pigs	33	270	21	
Loss of seedstock sales	-	4,002	848	
Loss of feeder pig sales	-	4,132	673	
Loss of other livestock	-	355	173	
Total cost per herd	3,939	12,622	2,441	
Average herd size	111	120	73	
Average cost per sow	35	105	33	138[b]

[a]The cost of the losses at farrowing and mortality of nursing and feeder pigs were lumped into a single figure for PA.

[b]Determined by a computer simulator model, not by survey of pilot project herds.

Table 5. Producer Cost Per Herd of Eradicating Pseudorabies in the Iowa Pilot Project, 1985

Item	Test and removal	Offspring segregation	Depopulation/repopulation FF	FPF
	- - - - - - - - - - - - $	- - - - - - - - - - - -		
Downtime	0	0	12,990	0
Depopulate	0	3,227		0
Cleanup				
Labor	0	89	1,200	6
Supplies	0	26	84	10
Segregating				
Labor	0	28	900	90
Facilities	0	0	1,324	400
Testing				
Initial herd test	-			
Subsequent	63	46	113	17
Loss selling "test and removal" positives	0	0		0
Vaccination				
Labor	30	68	900	0
Cost/herd	93	3,484	17,511	523
Cost/sow	1	29	146	
Cost/pig				0.30

[a]Test and removal was used to clean up 5 breeding herds.

[b]Offspring segregation was used to clean up 14 breeding herds.

[c]FF = Farrow to finish. Depopulation was used to clean up 1 farrow to finish herd.

[d]FPF = Feeder pig finisher. Depopulation was used to clean up 3 feeder pig finisher herds.

Table 6. Producer Costs Per Herd of Eradicating Pseudorabies in the Pennsylvania, Wisconsin, and Illinois Projects Compared to Offspring Segregation Plan in Iowa, 1985

Item	Pennsylvania	Wisconsin	Iowa	Illinois
	$			
Downtime	39,072	5,785		53,937
Depopulate	14,675	2,350	3,227	
Cleanup				
Labor	975	136	89	
Supplies	334	355	26	
Segregating				
Labor	18	526	28	
Facilities		522	0	
Testing				
Initial herd test	45	37		
Subsequent	42	63	46	
Loss selling "test and removal" positives		275		
Vaccination labor			68	
Total	55,161	10,049	3,484	

Pennsylvania: Costs are for the depopulation method only. The average downtime was 7.4 months per herd, which is the reason for the high cost of downtime.

Wisconsin: Pseudorabies was eradicated in some herds by the depopulation method and in some by the test and removal method. The costs reported in this table are the average costs for both groups of herds.

Illinois: The depopulation cost was estimated for a 100-sow herd by using a simulation model, not from survey data of pilot project herds that had eradicated pseudorabies. The computer model calculated costs for depopulating and replacing the breeding herd with bred gilts and the cost of lost production (downtime). The calculated cost amounted to $53,937 per herd.

Table 7. Public Cost of Vaccination, Blood Collection, and Laboratory Testing Fees to Eradicate Pseudorabies in the Iowa Project, July 1, 1983, to September 30, 1985

Item of cost	Cost/ sow/yr	Cost/ herd/yr	Project cost, 27 mo
	- - - - - - - - - - - -	$ - - - - - - - - - - - -	
Negative herds			
Surveillance[a]	1.73	174	61,534
Vaccination	1.50	91	31,672
Positive herds[b]	11.86	1,519	97,940
Plan A	4.10	459	3,208
Plan B	11.67	1,686	86,092
Plan C	29.09	1,369	8,641

[a]Surveillance includes blood collection and laboratory fees for serology.

[b]Plan A = test and removal, Plan B = offspring segregation, and Plan C = depopulation/repopulation.

Table 8. Itemized Public Costs of Eradicating Pseudorabies in the Pilot Projects

Item	Illinois[a]	Iowa[a]	North Carolina[b]	Pennsylvania[c]	Wisconsin[c]
	- - - - - - -	- - - - - - -	- - - - - $	- - - - - - -	- - - - - - -
Laboratory					
Technicians				44,000	
Testing	19,242	22,178	32,322		19,022
Overhead				70,000	
Field work					
Herd plan		51,810			23,515
Testing					3,165
Veterinarians	37,200	14,350		90,000	
Technicians	1,650			54,000	
Veterinary pathologist				45,000	
Salaries			246,270		
Administrative	not included	17,270		25,000	51,595
Support staff	35,910	29,616		30,000	17,616
Travel	30,080	6,739	53,031	13,500	845
Supplies	13,618	983	10,312	35,000	
Fee basis testing	15,532	48,608	28,153		2,034
Vaccine		105,552			
Indemnity					1,475
TOTAL	153,232	297,106	370,088	406,500	119,267

[a]The public costs for IL and IA are for 27 months of pilot project activity, July 1, 1983, to September 30, 1985.

[b]The public costs for North Carolina are for 15 months, March 1, 1984 to May 30, 1985.

[c]The public costs for PA and WI are for 1 fiscal year, October 1, 1984, to September 30, 1985.